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EDITORS FOREWORD

Dear readers,

We are pleased to present the second issue of Kinesiology Slovenica for July 2024. This issue contains nine exceptional articles from different countries that emphasize our commitment to international collaboration and knowledge sharing in kinesiology. Topics range from the rehabilitation of patients with coronary artery disease to the effects of various programs on different variables such as aggression in obese children, symptoms of attention deficit hyperactivity disorder, vitality and respiratory fitness, body composition, vertical jump performance, and academic performance. Once again, we have demonstrated the diversity of the contributions by emphasizing the interdisciplinary nature of kinesiology and its profound impact on human health, performance and well-being.

We sincerely thank the authors for their contributions and our esteemed reviewers for their expertise and critical insights that ensured the high quality of this issue. Thank you for joining us on this remarkable journey.

With best regards,

Assist. Prof. Dr. Sasa Duric

Deputy Editor-in-Chief

PREDGOVOR

Spoštovani bralci,

Z veseljem vam predstavljamo drugo številko Kinesiologia Slovenica za julij 2024. Ta številka vsebuje devet izjemnih člankov iz različnih držav, ki poudarjajo našo zavezanost k mednarodnemu sodelovanju in izmenjavi znanj na področju kineziologije. Teme segajo od rehabilitacije bolnikov s koronarno arterijsko boleznijo do učinkov različnih programov na različne spremenljivke, kot so agresivnost pri debelih otrocih, simptomi motnje pozornosti in hiperaktivnosti, vitalnost in dihalna sposobnost, telesna sestava, zmogljivost navpičnega skoka in učna uspešnost. Ponovno smo dokazali raznolikost prispevkov s poudarjanjem interdisciplinarnosti kineziologije in njenega globokega vpliva na človekovo zdravje, zmogljivost in dobro počutje.

Iskreno se zahvaljujemo avtorjem za njihove prispevke in našim cenjenim recenzentom za njihovo strokovno znanje in kritične vpoglede, ki so zagotovili visoko kakovost te številke. Hvala, ker ste se nam pridružili na tem izjemnem potovanju.

Z lepimi pozdravi,

Doc. Dr. Saša Đurić

Namestnik odgovornega urednika

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MANAGING LIPID LEVELS IN THE LIFE-LONG REHABILITATION OF PATIENTS WITH CORONARY ARTERY DISEASE

OBVLADOVANJE RAVNI KRVNIH MAŠČOB V PROCESU VSEŽIVLJENJSKE REHABILITACIJE KORONARNIH BOLNIKOV

ABSTRACT

Cardiac rehabilitation includes secondary prevention of cardiovascular events. Since the level of LDL cholesterol, which is an important risk factor for cardiovascular events, had been shown to be insufficiently controlled in persons included in the third phase of cardiac rehabilitation in the Coronary Club of Ljubljana, we aimed to explore if an additional educational program would improve the control of blood lipids and self-management ability in these subjects. Members of the Coronary Club of Ljubljana were invited to join a ten-month structured program for the management of cardiovascular risk factors with an emphasis on lipid control. Participation in the program activities was optional. A total of 146 subjects were enrolled. During the study, a slight decrease was seen in the following parameters: total cholesterol, HDL cholesterol, triglycerides and glycated haemoglobin ($p < 0.05$). In the whole group of participants, the median LDL cholesterol level decreased from 2.5 mmol/L (interquartile range [IQR], 1.8-3.4) to 2.2 mmol/L (IQR, 1.7-3.5), but the difference was not statistically significant ($p = 0.081$), while in the participants who attended individual consultations or workshops, a significant decrease in LDL cholesterol levels was observed. At the beginning of the study, very high-risk patients had higher activation, indicated with higher median baseline Patient Activation Measure (PAM) score, than high-risk patients (60.6 versus 55.6). During the study, the median PAM score increased in high-risk patients (from 55.6 to 60.6), but not in very high-risk patients. Thus, an additional educational program can improve lipid control and patient activation in subjects included in the third phase of cardiac rehabilitation.

Keywords: cardiac rehabilitation, control of blood lipids, patient activation

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IZVLEČEK

Kardiološka rehabilitacija vključuje sekundarno preventivo srčno-žilnih dogodkov. V Koronarnem klubu Ljubljana smo pri osebah, vključenih v tretjo fazo kardiološke rehabilitacije, ugotovili nezadovoljivo urejeno raven holesterola LDL, ki je pomemben dejavnik tveganja za srčno-žilne dogodke. Zato smo želeli raziskati, ali bi dodatni izobraževalni program pri teh osebah izboljšal nadzor maščob v krvi in zmožnost, da skrbijo za svoje zdravje. Člani Koronarnega kluba Ljubljana so bili povabljeni v desetmesečni strukturirani program obvladovanja srčno-žilnih dejavnikov tveganja s poudarkom na nadzoru krvnih maščob. Udeležba na posameznih programskih aktivnostih je bila prostovoljna. Skupno je bilo vključenih 146 oseb. Do zaključka programa so se nekoliko zmanjšale vrednosti naslednjih parametrov: skupnega holesterola, holesterola HDL, trigliceridov in glikiranega hemoglobina ($p < 0,05$). V celotni skupini sodelujočih se je mediana raven holesterola LDL znižala z 2,5 mmol/L (kvartilni razpon [IQR]: 1,8-3,4) na 2,2 mmol/L (IQR: 1,7-3,5), vendar razlika ni bila statistično značilna ($p = 0,081$), medtem ko se je pri udeležencih, ki so obiskali individualna svetovanja ali delavnice, raven holesterola LDL statistično značilno znižala. Na začetku raziskave so bili bolniki z zelo velikim tveganjem za srčno-žilne dogodke bolje aktivirani, kar je pokazala višja mediana izhodiščna ocena po vprašalniku PAM, kot bolniki z velikim tveganjem (60,6 proti 55,6). Do zaključka raziskave se je mediana ocena Patient Activation Measure (PAM) zvišala pri bolnikih z velikim tveganjem (s 55,6 na 60,6), ne pa pri bolnikih z zelo velikim tveganjem. Z dodatnim izobraževalnim programom je v tretji fazi kardiološke rehabilitacije torej mogoče izboljšati nadzor krvnih maščob in močneje aktivirati bolnike pri skrbi za svoje zdravje.

Ključne besede: kardiološka rehabilitacija, nadzor krvnih maščob, aktivacija bolnikov

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INTRODUCTION

Comprehensive cardiac rehabilitation includes assessment of risk factors, patient empowerment, psychosocial support and secondary prevention – which involves regular physical exercise, appropriate diet, the avoidance of smoking, and pharmacological treatment. It has been proven that with organized cardiac rehabilitation for coronary patients the number of hospitalizations and the risk of death from cardiovascular disease (CVD) can be reduced and the quality of life improved (Anderson et al., 2016).

The Coronary Club of Ljubljana (KKL) is a centre for the third phase of cardiac rehabilitation and it has been rehabilitating heart patients since 1981. An important part of cardiac rehabilitation is regular physical exercise, which in KKL includes specialised methods, such as a triangular model of dynamic aerobic exercise, synchronized cardiorespiratory rehabilitation (the G-I-O program) (Fras et al., 2019), and exercise in the sitting position for cardiovascular patients with locomotor disability.

Another important task of the KKL is prevention of cardiovascular events through lifestyle changes and risk factor control. In a recent systematic assessment of the management of cardiovascular risk factors in members of KKL we found a good control of blood pressure and blood sugar. Further, the number of smokers among the members was very small. On the contrary, body weight and cholesterol levels were not controlled sufficiently since only 16% of patients achieved a low-density lipoprotein (LDL) cholesterol level below 1.8 mmol/L, which was the target value for secondary prevention at the time of the analysis. Among the patients who had had myocardial infarction, 24% achieved this target (Rakar & Simpson Grom, 2020).

It is known that LDL cholesterol plays a key role in atherosclerosis, thus controlling this risk factor is very important in the prevention of CVD, as emphasised in the current guidelines of the European Society of Cardiology. According to these guidelines, a serum level of LDL cholesterol below 1.4 mmol/L is recommended for patients with coronary artery disease. The key measures to achieve this goal are a healthy diet and the use of appropriate medications (Visseren et al., 2021).

It has been shown that patients with CVD have higher serum levels of lipoprotein(a) than persons without CVD and several prospective studies confirmed that an elevated level of lipoprotein(a) is a risk factor for atherosclerotic CVD (Danesh et al., 2000, Kronenberg et al., 2022). While the relationship between lipoprotein(a) concentration and cardiovascular outcomes is linear, a threshold of 300 mg/L, which indicates a clinically significant increase in

CVD risk, has been suggested for persons without previous cardiovascular events (Kronenberg et al., 2022). An elevated level of lipoprotein(a) has been shown to be associated with an increased risk of cardiovascular events also in individuals with established atherosclerotic cardiovascular disease (Berman et al., 2024).

Patient activation, which describes the knowledge, skills, and confidence a person has in managing their health and healthcare, is an important aspect of self-management for adults with chronic health conditions. The Patient Activation Measure (PAM) has become the most used tool to measure this parameter (Hibbard et al., 2005, Roberts et al., 2016).

This study aims to evaluate the effects of an additional educational rehabilitation program on the control of blood lipids and on self-management ability in persons with increased cardiovascular risk or stable cardiovascular disease who were included in a comprehensive rehabilitation program in the KKL.

METHODS

Participants

All members of the KKL with stable coronary disease (at least 6 months since myocardial infarction or at least 3 months since percutaneous or surgical revascularization of coronary arteries) and members without established atherosclerotic cardiovascular disease but with increased cardiovascular risk (because of the presence of risk factors such as arterial hypertension or hypercholesterolemia) were invited to join a structured program for the management of cardiovascular risk factors with an emphasis on lipid control. The exclusion criteria were: severe or uncontrolled heart failure, uncontrolled heart rhythm disorders, severe or uncontrolled heart valve disease, recent inflammation of cardiac muscle (less than 6 months ago) or pericardium (less than 3 months ago).

The study was approved by the National Medical Ethics Committee (no. 0120-43/2022/4) and was conducted in accordance with the Declaration of Helsinki. The participants were informed about the study procedures and provided written informed consent prior to inclusion into the study.

Interventions

The participants were included in a ten-month (from 2022 to 2023) structured program for the management of cardiovascular risk factors with an emphasis on lipid control, which offered the following services:

- individual consultations with a cardiologist focused on the management of cardiovascular risk factors, especially blood lipids (15 minutes each);
- workshops with a cardiologist on the importance of lipid control and taking medication (1 hour each);
- stress management workshops (1 hour each);
- nutrition workshops with a clinical dietitian (1 hour each).

Participation in these activities was optional.

All participants continued with their regular rehabilitation exercise (twice a week for 45 minutes), which included specialized methods, such as a triangular model of dynamic aerobic exercise, the G-I-O program, or exercise in the sitting position for cardiovascular patients with locomotor disability. A triangular model of dynamic aerobic exercise is based on the integration of G-I-O elements, elements for mobility of the spine and joints, and elements for strengthening the body using free weights of up to 1 kg or one's own weight. G-I-O is an integrated method, which connects breathing, sensorimotor functions and higher brain processes. It is based on the synchronization of body movements with breathing and was described in detail elsewhere (Fras et al., 2019).

Measured parameters

Data on age, gender, medical history, cardiovascular risk factors (arterial hypertension, diabetes, dyslipidaemia, smoking), and regular drug therapy was gathered. Body weight and height as well as a serum level of lipoprotein(a) were measured at baseline.

Serum lipids (total cholesterol, LDL cholesterol, high-density lipoprotein [HDL] cholesterol, and triglycerides) and glycated haemoglobin (the percentage of haemoglobin that is bound to glucose, which provides a reflection of blood glucose control over a longer period of time) were measured after fasting at baseline and after the ten-month program.

Before and after the program the six-minute walk test was performed to measure aerobic exercise capacity. This test measures the distance that a patient can quickly walk on a flat, hard surface in a period of 6 minutes (ATS, 2002).

At baseline and after the program the participants completed a Short Form of PAM (PAM-13; the Slovenian version), which is a 13-item questionnaire for assessment of the patient's self-reported knowledge, skill, and confidence in the self-management of their health or chronic condition. The PAM survey measures patients on a 0–100 scale and segments them into one of four activation levels along an empirically derived continuum, where 1 and 4 denote the lowest and highest level of patient activation, respectively (Hibbard et al., 2005).

Statistical analysis

The data was summarized with descriptive statistics. Differences between 2023 and 2022 (value in 2023 minus value in 2022) were tested using the nonparametric Wilcoxon test for dependent samples in the case of not normally distributed data (e.g. serum lipids, glycated haemoglobin, the PAM score) or the t-test for dependent samples in case of normally distributed data (e.g. the six-minute walk test).

Since the values of lipoprotein(a) were not normally distributed, Spearman's correlation was used to evaluate the association between lipoprotein(a) and the numerical variables. To evaluate the association between lipoprotein(a) and the categorical variables, the non-parametric Wilcoxon test for independent samples (in case of two samples) or the Kruskal-Wallis test (in case of more than two samples) was used.

The association between the PAM score and the studied parameters of cardiovascular risk was evaluated using Spearman's correlation in the case of numerical variables and the nonparametric Wilcoxon test for independent samples in case of categorical variables.

The programs IBM SPSS Statistics for Windows and Microsoft Excel were used for data analysis.

Since a large number of statistical tests can increase the chance of making a type I error, the calculated p-values should be understood in a descriptive sense. Thus, the performed statistical analysis is of an exploratory nature, which means that the results can be interpreted in terms of hypothesis generation and not hypothesis confirmation.

RESULTS

Participant characteristics

A total of 146 patients were enrolled in the study, 98 (67%) of whom were females. The median age of the participants was 74.0 years (interquartile range [IQR], 69.8-79.0). The median body mass index (BMI) was 27.1 kg/m² (IQR, 24.9-29.0).

The most frequently reported diagnoses were myocardial infarction (30.8%), arterial hypertension (29.5%), heart failure (25.3%) and hypercholesterolemia (21.2%). More than a third of patients (38.4%, N=56) belonged to the very high cardiovascular risk category. At baseline, 55 patients (37.7%) were receiving lipid-lowering medications.

Participation in the program activities

Of 146 included patients, 84 participated in at least one program activity, while 62 did not participate in any activity. The numbers of patients who participated in workshops and individual consultations are shown in Table 1.

Table 1. Participation in workshops and individual consultations.

Activity	Number of participants
Individual consultation with a cardiologist	20
Workshop with a cardiologist	59
Stress management workshop	16
Nutrition workshop	43

Changes of the measured parameters

A slight decrease was seen in the following parameters: total cholesterol, HDL cholesterol, triglycerides and glycated haemoglobin ($p < 0.05$) (Table 2).

Table 2. Measured parameters before (2022) and after (2023) the ten-month structured program for the whole group of participants (N=146).

Variable	2022	2023	P-value*
Total cholesterol (mmol/L)	4.2 (3.5-5.3)	4.1 (3.4-5.2)	0.026
LDL cholesterol (mmol/L)	2.5 (1.8-3.4)	2.2 (1.7-3.5)	0.081
HDL cholesterol (mmol/L)	1.3 (1.1-1.6)	1.3 (1.1-1.5)	0.002
Triglycerides (mmol/L)	1.1 (0.9-1.4)	1.0 (0.8-1.4)	0.012
Glycated haemoglobin (%)	5.6 (5.3-5.9)	5.5 (5.3-5.9)	0.002
Six-minute walk test (m)	512 (451-584)	512 (455-603)	0.981
PAM score (points)	58.1 (51.0-70.2)	60.6 (51.0-67.8)	0.261

Notes. All variables are expressed as medians and interquartile ranges. *For the difference between 2023 and 2022. PAM, Patient Activation Measure.

LDL cholesterol

In the whole group of participants, the median LDL cholesterol level decreased from 2.5 mmol/L (IQR, 1.8-3.4) in 2022 to 2.2 mmol/L (IQR, 1.7-3.5) in 2023, but the difference was not statistically significant ($p=0.081$) (Table 2). The number of participants who achieved the target level of LDL cholesterol for secondary prevention of CVD (below 1.4 mmol/L) increased from 13 (8.9%) to 16 (11.0%) (Table 3).

Table 3. Number of participants in different LDL cholesterol categories in 2022 and 2023 (N=146).

LDL cholesterol (mmol/L)	2022 N (%)	2023 N (%)
<1.4	13 (8.9)	16 (11.0)
1.4-2.6	62 (42.5)	67 (45.9)
2.7-3.6	36 (24.7)	30 (20.5)
>3.6	35 (24.0)	33 (22.6)

In the subgroup of participants who were at very high cardiovascular risk (N=56) the median LDL cholesterol level decreased from 1.9 mmol/L (IQR, 1.6-2.6) to 1.8 mmol/L (IQR, 1.5-2.2), which was not statistically significant ($p=0.128$).

In the participants who attended individual consultations or workshops within the program, a significant decrease in LDL cholesterol levels was observed, while LDL cholesterol levels did not decrease in persons who did not participate in these additional activities (Table 4).

Table 4. Levels of LDL cholesterol in 2022 and 2023 according to the participation in different activities.

Activity	Number of participants	LDL cholesterol (mmol/L)		P-value*
		2022	2023	
Individual consultation with a cardiologist	20	3.7 (2.1-4.4)	3.1 (1.8-4.0)	0.001
Workshop with a cardiologist	59	2.6 (1.8-4.0)	2.0 (1.6-3.3)	<0.001
Stress management workshop	16	2.7 (1.8-3.5)	2.2 (1.7-3.3)	0.010
Nutrition workshop	43	2.6 (1.8-3.7)	2.0 (1.6-3.0)	<0.001

Notes. Values of LDL cholesterol are expressed as medians and interquartile ranges. *For the difference between 2023 and 2022.

Lipoprotein(a)

The median level of lipoprotein(a), which was measured at baseline in 144 participants, was 23 nmol/L (IQR, 10-103). Forty-eight participants (33.3%) had a lipoprotein(a) level above 64 nmol/L, which was the laboratory reference value associated with a significantly increased cardiovascular risk. There were no statistically significant associations between lipoprotein(a) and other laboratory parameters.

PAM score

A total of 123 participants completed the PAM questionnaire. The median PAM score was 58.1 (IQR, 51.0-70.2) in 2022 and 60.6 (IQR, 51.0-67.8) in 2023, but the difference was not statistically significant ($p=0.261$) (Table 1). During the study the number of participants in PAM level 1 decreased and the number of participants in PAM levels 2 and 3 increased (Table 5).

Table 5. Number of participants in each PAM level in 2022 and 2023 (N=123).

PAM level	2022 N (%)	2023 N (%)
1	9 (7.3)	1 (0.8)
2	37 (30.1)	39 (31.7)
3	51 (41.5)	57 (46.3)
4	26 (21.1)	26 (21.1)

The PAM score varied based on cardiovascular risk in 2022. Very high-risk patients (N=45) had higher median PAM score than high-risk patients (N=78) (60.6; IQR, 55.6-80.9 versus 55.6; IQR, 51.0-65.5; $p=0.018$). There was no difference in median PAM score based on cardiovascular risk in 2023. The median PAM score increased significantly in high-risk patients (from 55.6; IQR, 51.0-65.5 to 60.6; IQR 51.0-65.5; $p=0.018$).

No statistically significant change in PAM score was observed in subgroups of participants who attended individual consultations or workshops within the program.

DISCUSSION

A significant decrease in LDL cholesterol was observed in our patients after taking part in a ten-month structured program for the management of cardiovascular risk factors. This suggests that individual consultations in combination with workshops providing education on the importance of reaching LDL cholesterol targets and healthy eating may be helpful in lipid management. The number of participants in our study who achieved the target level of LDL cholesterol for secondary prevention of CVD (below 1.4 mmol/L) increased from 13 (8.9%) to 16 (11.0%). In the international cross-sectional survey EUROASPIRE V, which included coronary patients and was conducted also in Slovenia, LDL cholesterol below 1.8 mmol/L (the target level for secondary prevention of CVD at the time of the survey) was achieved by 29% of subjects (Kotseva et al., 2019). In our study, LDL cholesterol below 1.8 mmol/L was achieved by 45 participants (30.8%) before and 49 participants (33.6%) after the structured program.

Forty-eight participants (33.3%) in our study had a lipoprotein(a) level above 64 nmol/L, which was the laboratory reference value indicating a significantly increased cardiovascular risk. Studies have confirmed that elevated lipoprotein(a) levels are associated with an increased risk

of cardiovascular events also in patients with coronary heart disease (Shiyovich et al., 2023, Zhang et al., 2023). However, the comparability between the studies is limited due to different lipoprotein(a) assays, measurement units (mg/dL or nmol/L) and cut-off values used. Lipoprotein(a) concentration is predominantly determined by genetics and can be only minimally influenced by lifestyle interventions. According to European Atherosclerosis Society recommendations, a high lipoprotein(a) concentration should be interpreted in the context of other risk factors and absolute global cardiovascular risk, and addressed through intensified risk factor management (Kronenberg et al., 2022).

Patient activation was associated with health outcomes in published studies. Patients with acute decompensated heart failure with lower activation more often required skilled care and had higher 30-day mortality compared to patients with higher activation (Dunlay et al., 2017). Similarly, hospital survivors of an acute coronary syndrome with the lowest level of patient activation were more likely to experience clinically meaningful declines in generic mental and disease-specific health-related quality of life compared with the most highly activated patients in the 6 months following hospital discharge (Erskine et al., 2018). At the beginning of our study, very high-risk patients had higher activation, indicated with higher median baseline PAM score, than high-risk patients (60.6 versus 55.6). This difference in baseline PAM score could be explained by the fact that the subgroup of very high-risk patients mainly included patients after myocardial infarction, who had already undergone the second phase of cardiac rehabilitation and were therefore better equipped to take care of their health. During the study, the median PAM score increased only in high-risk patients (from 55.6 to 60.6), in whom it reached the same level as it had been measured in very high-risk patients. Compared to our results, higher PAM scores were found in the study from United Kingdom, which included patients participating in routine cardiac rehabilitation, using a customisable telemetry system; participating in this rehabilitation program led to an increase in median PAM score from 65.5 to 70.2 (Frith et al., 2021). In a study from Denmark, which compared two different models of coronary patient education to each other, mean PAM scores of 64.47 and 64.95 were achieved (Pedersen et al., 2022).

Limitations

The present study has some limitations. First, the sample size was relatively small. Second, the majority (67%) of participants were women although in general population age-standardized rates of both morbidity and death from CVD are higher in men than in women (Townsend et

al., 2022). Third, members of KKL, who participated in the study, belonged to a selected population of patients with high awareness of CVDs. These are the reasons why the generalizability of our findings to a general population of patients with CVD is limited.

CONCLUSION

We have shown that an additional educational program can improve lipid control and patient activation in subjects who are included in the third phase of cardiac rehabilitation. However, as the majority of our participants still did not reach their target levels of LDL cholesterol at the end of the program, more studies are needed to explore additional measures for improving lipid control in subjects with an increased cardiovascular risk in a real-life setting. Since our sample of participants represent only a small part of the whole population of cardiovascular patients, the question remains if this approach could be successfully applied to a broader population. This warrants further research.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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MEDIATING ROLE OF PRENATAL ANDROGENS, MUSCLE STRENGTH AND PHYSICAL ACTIVITY ON AGGRESSION IN OBESE AND OVERWEIGHT CHILDREN AND ADOLESCENTS

POSREDNIŠKA VLOGA PRENATALNIH ANDROGENOV, MIŠIČNE MOČI IN TELESNE DEJAVNOSTI PRI AGRESIVNOSTI DEBELIH IN PREKOMERNO TEŽKIH OTROK TER MLADOSTNIKOV

ABSTRACT

Obesity in children and adolescents is a global health problem associated with behavioral issues like aggression which can lead to developmental problems. High levels of prenatal androgens may play a role between obesity and aggression. This study examined the relationship between obesity, aggression and the mediating role of prenatal androgens, muscle strength and physical activity in children and adolescents. 118 healthy boys ages 9 to 17 participated and researchers measured their height, weight, body composition, muscle strength, second to fourth finger ratio, physical activity level using PAQ, and aggression using BPAQ. Chi-square test, Pearson's correlation, stepwise linear regression, and Sobel's test were used to examine relationships between variables and test mediation, seeking to identify factors affecting aggressiveness. The study found that aggression is directly related to weight, BMI, muscle mass, body fat and WHR. Obese people were more likely to be aggressive compared to non-obese people. Regression analysis showed that 2D:4D ratio, muscle mass and BMI can predict aggression. The results also showed that only muscle strength mediates the relationship between body mass and aggression. The study found a direct link between aggression and body mass in boys which may be because muscle strength mediates this relationship. The findings agree with the idea that prenatal androgens affect aggression in boys. Obese children with low 2D:4D ratios may need education to change views, values, and increase physical activity.

Keywords: aggression, prenatal androgens, physical activity, strength, obesity

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IZVLEČEK

Debelost pri otrocih in mladostnikih je globalni zdravstveni problem, povezan z vedenjskimi težavami, kot je agresivnost, ki lahko vodijo do razvojnih težav. Visoke ravni prenatalnih androgenov lahko igrajo pomembno vlogo pri povezavi med debelostjo in agresivnostjo. Ta študija je preučevala odnos med debelostjo, agresivnostjo in posredniško vlogo prenatalnih androgenov, mišične moči in telesne dejavnosti pri otrocih in mladostnikih. V raziskavo je bilo vključenih 118 zdravih dečkov, starih od 9 do 17 let, pri čemer so raziskovalci izmerili njihovo višino, maso, telesno sestavo, mišično jakost, razmerje med drugim in četrtim prstom, raven telesne dejavnosti z uporabo PAQ in agresivnost z uporabo BPAQ. Za preučevanje odnosov med spremenljivkami in testiranje mediacije so uporabili hi-kvadrat test, Pearsonov korelacijski koeficient, postopno linearno regresijo in Sobelov test, s ciljem prepoznati dejavnike, ki vplivajo na agresivnost. Študija je pokazala, da je agresivnost neposredno povezana z maso, indeksom telesne mase (ITM), mišično maso, telesno maščobo in razmerjem med obsegom pasu in bokov (WHR). Debeli posamezniki so bili bolj verjetno agresivni v primerjavi z normalno težkimi posamezniki. Regresijska analiza je pokazala, da lahko razmerje 2D:4D, mišična masa in ITM napovedujejo agresivnost. Rezultati so pokazali, da samo mišična moč posreduje odnos med telesno maso in agresivnostjo. Študija je odkrila neposredno povezavo med agresivnostjo in telesno maso pri dečkih, kar je lahko posledica tega, da mišična moč posreduje ta odnos. Ugotovitve se strinjajo z idejo, da prenatalni androgeni vplivajo na agresivnost pri dečkih. Debeli otroci z nizkimi razmerji 2D:4D morda potrebujejo izobraževanje za spremembo pogledov, vrednot in povečanje telesne aktivnosti.

Ključne besede: agresivnost, prenatalni androgeni, telesna dejavnost, mišična jakost, debelost

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INTRODUCTION

Obesity and overweight are gradually increasing as a global health challenge across all age groups, with a particularly concerning impact on children and adolescents. In 2016, approximately 17% of children and adolescents worldwide were classified as overweight or obese (Cheng et al., 2022). Using body mass index (BMI) as a measure, roughly 1 out of every 5 individuals globally falls into the obese or overweight category. Among adolescents aged 12 to 19 years, severe obesity has seen a slight increase, affecting over 9% of this age group in the last two decades (Ogden et al., 2016).

In Iran, a meta-analysis conducted by Khazaei et al. (2017) estimated the prevalence of obesity among boys to be approximately 6.85%, while in girls, it was approximately 5.13% (Khazaei et al., 2017). However, recent meta-analysis studies have reported a higher percentage of obesity and overweight, ranging from 9.4% to 13.7%, in Iranian children (Akbari, & Mohammadi, 2022).

The physical and psychosocial consequences of obesity in childhood and adolescence are widespread. Some of the adverse physical consequences of obesity/overweight are well documented, such as cardiovascular diseases, metabolic syndrome, type II diabetes, hypertension, hyperlipidemia, orthopedic disorder, sleep apnea, asthma, and fatty liver (Andrade & Alves, 2019). However, research on the psychological, social, and behavioral consequences of obesity in childhood and adolescence is still underway. Research findings, in this case, have shown that children with obesity are at risk of low self-esteem, increased body dissatisfaction, depression, and social isolation and discrimination (Cheng et al., 2022).

Obesity is a circumstance that can create diverse unruly behaviors in children and teenagers. One of the prevalent antisocial behaviors that result from corpulence is aggression. Aggression can cause unsafe environment for other children and can show forthcoming issues like delinquency, depression, drug abuse misuse, and scholastic failure (Motlagh, Ahmadi, Jalilian, Mirzaei, Aghaei, & Karimzadeh, 2013). Aggression can be a forerunner to diverse developmental complications such as physical and mental health distortions, including temper disorders, anxiety, and psychosis (Tso, Rowland, Toumbourou, & Guadagno, 2018). Studies conducted in both Australia and the United States have found that approximately 18 to 33% of children and adolescents display physically aggressive behaviors (Tso et al., 2018). Similarly, studies directed in Iran have announced that between 30-50% of children and teenagers display aggression (Motlagh et al., 2013). While research has been led on the relationship between

overweight/obesity and aggression in children, the results have been contradictory. Some studies have announced an important relationship between obesity and aggressive behavior, while others have not found any important connection. Furthermore, gender differences have brought about mixed results. However, studies conducted on both boys and girls show that there is an important association between excess weight/obesity, and aggressive behaviors in girls only, while others found an important association between overweight/obesity and aggression in boys only (Tso et al., 2018). The contradictory results may be due to other environmental and genetic factors affecting aggression. Generally, the correlation between obesity and aggression in children is a complex issue that requires further investigation. It is important to recognize the negative impact of obesity on a child's behavior and take appropriate actions to address it.

Various elements, including biological, social, and cultural factors influences can lead to aggressive behaviors that continuously influence one another. Thus, to mitigate aggressive behaviors, interventions may need to address the biological, environmental, and sociocultural aspects together. Among the biological factors, testosterone has been extensively studied (Vigil, Del Río, Carrera, ArÁnguiz, Rioseco, & Cortés, 2016). Another gender characteristic that has been linked to aggressive behavior is the second-to-fourth digit ratio (2D:4D), which is typically higher in women than in men (Mikac, Buško, Sommer, & Hildebrandt, 2016). This ratio is established around the fourth month of pregnancy under the influence of prenatal sex hormones. The higher the testosterone-to-estrogen (T/E) ratio, the smaller the 2D:4D ratio, leading to more masculine characteristics. Conversely, a larger ratio of 2D:4D indicates female typicality (Fink, Neave, Laughton, & Manning, 2006). As a result, the 2D:4D ratio can help determine the levels of progenitor androgens (Mikac et al., 2016). Prenatal sex hormones create morphological and neurological differences that can affect sex differences in behavior (Marina Butovskaya, Burkova, Karelin, & Fink, 2015). The brain's sexual differentiation follows a similar pattern with morphological characteristics, such that the presence of testosterone makes the tissue more masculine, while its absence makes it more feminine. These differences can also be noticed in personality traits (Fink et al., 2006). Therefore, there appears to be a probable relationship between the 2D:4D ratio and aggressive behavior. Many studies have shown such a connection among young men (Bailey & Hurd, 2005), black men and women (Marina Butovskaya et al., 2015), children and adolescents (M. Butovskaya, Burkova, Karelin, & Filatova, 2019), and pre-pubescent boys (Babarro et al., 2022). Additionally, a meta-analysis by Turanovic et al. (2017) found a weak but significant relationship among fetal testosterone, 2D:4D ratio, aggression,

and violent behavior (Turanovic, Pratt, & Piquero, 2017). However, other studies did not find a relationship between prenatal testosterone and aggressive behavior (Hilgard, Engelhardt, Rouder, Segert, & Bartholow, 2019; Joyner & Beaver, 2021).

Recent studies have examined the relationship between obesity and the second-to-fourth digit ratio as an indicator of prenatal androgens. Manning et al (2022) found an association between BMI and decreased prenatal testosterone, as well as increased prenatal estrogen levels. A similar link between the 2D:4D ratio and BMI was also found (Manning, Fink, Mason, & Trivers, 2022). Furthermore, this association has been established in other investigations with fat percentage (Bagepally, Majumder, & Kotadiya, 2020). Considering this dual relationship involving aggression with obesity and prenatal androgens, examining the mediating part of prenatal androgens, in this case, may be exceptionally valuable. These relationships grow to be more difficult when the interaction effect of some other factors in obesity, aggression, and prenatal androgens such as muscle strength and physical activity are also considered. The relationship between muscle strength and physical activity with the 2D:4D ratio and obesity has been well explained in two new studies (de Dios Benítez-Sillero, Corredor-Corredor, Portela-Pino, & Raya-González, 2022; Pasanen, Tomkinson, Dufner, Park, Fitzgerald, & Tomkinson, 2022). The relationship between physical activity and aggression has also been investigated in some studies, which show a significant and inverse relationship between aggression and physical activity. Additionally, some studies suggest that people with lower levels of physical activity tend to display more aggressive behaviors. The biological mechanisms behind this link are complex and may involve changes in endorphin and serotonin levels, as well as symptoms of depression and anxiety that can coincide with sedentary lifestyles. Furthermore, there is evidence to suggest that the correlation between aggression and delinquency is moderated by physical activity. Specifically, at high levels of physical activity, instrumental aggression is not associated with delinquency, whereas at low levels of physical activity, active aggression is positively correlated with delinquency. Therefore, physical activity may be an important factor in moderating the relationship between aggression and other Criminal behaviors (Fite & Vitulano, 2011; Ubago-Jiménez, Cepero-González, Martínez-Martínez, & Chacón-Borrego, 2021). The role of muscle strength, especially grip strength, has also been investigated in relation to aggression and the 2D:4D ratio, and the findings indicate a positive relationship between muscle strength and aggression and their relationship is a lower 2D:4D ratio (Ribeiro Jr et al., 2016).

Given the complex relationships between obesity, aggression, and factors like prenatal androgens, strength, and physical activity, investigating the potential mediating role of the 2D:4D ratio in the link between obesity and aggression is needed. While positive associations between obesity and aggression have been found, the influence of prenatal androgens as measured by the 2D:4D ratio has yet to be examined.

We hypothesize that specific biological and behavioral factors may help explain the link between being overweight and exhibiting aggressive behaviors. First, we will evaluate the correlation between aggression scores and measures of body composition, including body mass index, percentage of body fat, and waist circumference in our youth participants. If a significant relationship is found, we will then investigate whether and how much of this correlation can be attributed to one of three potential mediating factors: 2D:4D digit ratio, a proxy for prenatal hormone exposure; physical strength and muscle mass; and levels of physical activity. Answering these questions could uncover valuable new insights into the health risks facing overweight youth, aid in identifying those at risk of being both overweight and aggressive, and inform the design of effective intervention and prevention programs.

METHODS

Study participants

This study was cross-sectional correlational research. All male students in Iran (Mazandaran province) between the ages of 9 and 17 in the academic year 2019-2020 were included in the statistical population of this study, and the sample size was based on the average value of r obtained from past research (Tso et al., 2018) using G-Power software for correlational research. Male children and adolescents (0.24) and a significance level of 0.05, 218 people were considered. Sampling was done in a cluster-random manner (based on region and level) from three schools in the province. At first, in coordination with education, the necessary permission was issued to carry out work in schools. Following a visit to the school and agreement with the head teacher, an invitation to take part in the research was then sent to the parents of the students. After filling out the consent form and medical information questionnaire by the parents, the selected students were invited for evaluation according to the schedule.

Study instruments

All measurements were based on the international anthropometric standards provided by the International Society of Anthropology (ISAK)(Norton & Eston, 2019).

Obesity status: The subjects' height was measured using an AntroFlex wall-mounted studio meter with an accuracy of 0.1 m. To measure the weight, the subjects were asked to stand without shoes and in light sports clothes (sports shirt) and in a balanced position with their hands next to the body on a digital scale with an accuracy of 0.01 kg (BRISK, Germany) until the number fixed by the scale to show the subject's weight correctly. Body mass index (BMI), was calculated using the following formula:

$$\text{BMI} = (\text{Weight (kg)}) / ([\text{Height}]^2 \text{ (m)})$$

BMI values were divided into underweight, normal, overweight (pre-obesity), and obese groups based on the three classifications of cut points proposed by IOTF (Kelishadi et al., 2008).

Waist to hip ratio (WHR): a flexible 1.5-meter tape measure was used to measure this ratio. First, waist circumference was measured in the smallest diameter (usually 2.5 cm above the navel). Then the hip circumference was measured in the largest diameter of the hip area parallel to the ground. WHR was the ratio of waist circumference to hip circumference in cm.

Body composition: The two-point skinfold method of Slater et al. (1988) was used to evaluate body composition (Slaughter et al., 1988). For this purpose, the subcutaneous fat of the triceps and triceps (legs) was marked according to the measurement guide and measured three times by a trained examiner using a NUMED digital caliper (England). The average value of three measurements was considered in the calculation. Then, using the formula of Slaughter et al. (1988) for boys, the values of the percentage of procrastination were calculated.

$$\% \text{ Body Fat} = 0.735 (\text{Triceps} + \text{Calf}) + 1.0$$

2D:4D ratio: The length of the fingers was measured using the indirect measurement technique of Wisnapu et al. (2007). For this purpose, a trained examiner repeated the measurements twice for each subject (after practicing the measurement technique and reproducibility of the results several times). For the measurement, the subject was first asked to sit on a comfortable chair and place his hands on the grid paper placed on the table with the fingers extended and extended (in full abduction). Most of the subjects were asked to cut their nails completely. If needed, this was done by the researcher before the measurement. In this situation, the shape of the fingers was drawn by the examiner using a pen that was placed vertically on the paper. From the

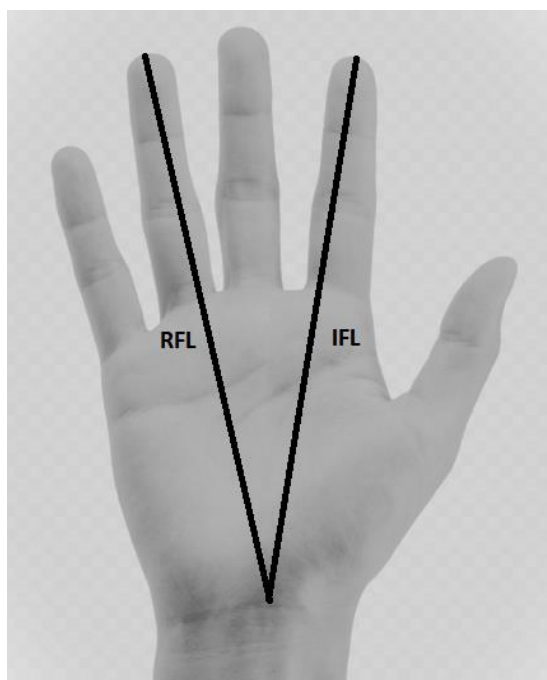
mentioned figure, finger length was measured using a caliper with 0.1 cm accuracy (Visnapuu & Jürimäe, 2007). The measurement method is shown in Figure (1):

The length of the index finger (2D): from the fold of the wrist, which is tangential to the horizontal line of the checkerboard as much as possible, to the tip of the forefinger.

The length of the ring finger (4D): from the crease of the wrist, which is tangential to the horizontal line of the checkerboard as much as possible, to the tip of the ring finger.

By dividing the average length of the second to the fourth digit, the 2D:4D ratio was calculated. The reliability of this measurement technique was calculated using the interclass correlation coefficient (ICC) to measure this ratio in two measurements 0.95 for the dominant hand and 0.94 for the non-dominant hand.

Figure 1. Measuring the length of the second and fourth digits.



Grip strength: A grip dynamometer (model SH5001, Saehan, South Korea) was used to evaluate grip strength. The movement of the handle in this dynamometer is not noticeable and uses a closed hydraulic system to activate the force indicator during muscle static action. Considering that the results of new research show that the values of the maximum power of the claw are higher in the standing position with outstretched hands (Xu, Gao, Xu, Zhou, & Guo, 2021), the measurement was done according to the standard method in this position (Xu et al., 2021). First, the dynamometer was adjusted according to the size of the subject's hand, so that the middle joint (second joint) of the middle finger (third finger) is almost at a right angle. Then the subject

was in a standing position, the head was in a vertical position (looking straight ahead); the arm was between 0 to 180 degrees of flexion; the elbow was in full extension and the wrist and forearm were in 90 degrees of pronation. In this situation, after hearing the examiner's command, the subject applied his maximum force for 3 to 5 seconds. During this time, the examiner verbally encouraged the subject with stronger words and more pressure. The subject repeated the test three times with a one-minute rest between them. The highest value obtained from three times of the test was considered as the value of the subject's hand grip strength (Xu et al., 2021).

Maturity status: The Iranian version of the maturity self-assessment questionnaire was used to determine maturity levels (Rabbani, Noorian, Fallah, Setoudeh, Sayarifard, & Abbasi, 2013). This questionnaire contained two series of illustrations depicting stages of genital development and patterns of pubic hair growth, evaluated as self-reports. Puberty was clinically diagnosed based on Tanner stages, which divides puberty among boys into five stages according to primary and secondary sexual characteristics, including changes in the penis and growth of pubic and axillary hair. In previous studies, this questionnaire had an acceptable reliability coefficient (Rabbani et al., 2013). To ensure the accuracy of the questionnaire results, some subjects were also examined by a general practitioner.

Physical activity: To measure the level of physical activity in this research, the Physical Activity Questionnaire of Children and Adolescents (PAQ-C) was used. This questionnaire includes 9 five-point Likert scale questions designed by Kowalski et al. (1997). The score of this questionnaire ranges from 1 to 5, where 1 indicates the lowest level of physical activity and 5 indicates the highest level of physical activity (Hajinia, Hamedinia, Haghghi, & Davarzani, 2013). The internal consistency of this test was reported as ranging from 0.79 to 0.89 using Cronbach's alpha, and its reliability ranged from 0.75 to 0.82 using test-retest. The criterion validity of this questionnaire shows favourable values when compared to other similar questionnaires (Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997). This questionnaire has previously been administered to Iranian children aged 12 to 16 (Hajinia et al., 2013).

Aggression: Bass and Perry's (1992) Standard Aggression Questionnaire (AGQ) was used as a self-report measure to measure aggression in this research. This questionnaire has 29 statements in which the subject evaluates his situation on a five-point Likert scale for each statement. People whose score is lower than the average in this scale will have low aggression and the higher the score of people in this test, the higher their aggression. The aggression questionnaire

has high internal consistency. In past studies in Iranian society, Cronbach's alpha coefficient for the total scores of the questionnaire was reported as 0.88, and for the subscales of physical aggression, verbal anger, and hostility between 0.72 and 0.84 (Amirkhanloo, Dousti, & Donyavi, 2022). The retest coefficient (retest) of the questionnaire was also reported in previous research as 0.8 (Amirkhanloo, Dousti, & Donyavi, 2022). In this study, Cronbach's alpha coefficient for the total score of the questionnaire was 0.85. The cut-off point of this questionnaire was 78 points, which is more or equal to this number as aggressive, and less than that is considered non-aggressive.

Statistical analyses

Descriptive statistics (mean and standard deviation) were used to classify and summarize the data. In order to determine the clinical relationship between obesity and aggression, initially, both variables were grouped based on the cut points suggested in previous studies, thereafter chi-square test was utilized to examine the relationship between them. Prior to inferential statistics, the distribution of each variable was checked. Owing to the normality of data distribution, Pearson's correlation coefficient and stepwise linear regression were used in two stages (while excluding the constant value and its associate) to investigate the relationship between the research variables. Moreover, Sobel's test was applied to check the mediating role of variables. For this purpose, the third version of the PROCESS plugin was added to the SPSS software package. This plugin designed by Hayes has the ability to calculate p-value for the Sobel test. Significance level considered $p \leq 0.05$.

RESULTS

Table 1 shows the descriptive indices of the key variables. These include mean, standard deviation, skewness and kurtosis. There was no significant violation of the normal condition (all skewness and kurtosis values were within ± 2). Therefore, Pearson correlation coefficient and linear regression were used to check the association between predictor variables and aggression.

Table 1. Descriptive indices of variables (n=218)

Variables	Mean	SD	Skewness	Kurtosis
Age (year)	13.77	2.4	-	-
Height (m)	1.59	0.16	-0.16	-0.92
Weight (Kg)	61.88	16.03	0.51	0.18
BMI (kg/m ²)	24.21	3.15	0.63	1.24
FFM (Kg)	47.27	11.69	0.17	-0.89
Body fat (%)	22.77	10.00	0.63	-0.63
WHR	0.87	0.082	0.56	-1.14
Grip strength (Kg)	40.36	10.49	0.35	-0.40
2D:4D ratio right	0.9928	0.0123	-0.69	0.36
2D:4D ratio left	0.9925	0.0124	-0.67	0.33
Physical activity	2.88	0.74	-0.39	-0.76
Aggression	72.29	11.42	0.31	-0.22

Note. BMI: Body mass index; FFM: Fat free mass; WHR: waist-to-hip ratio

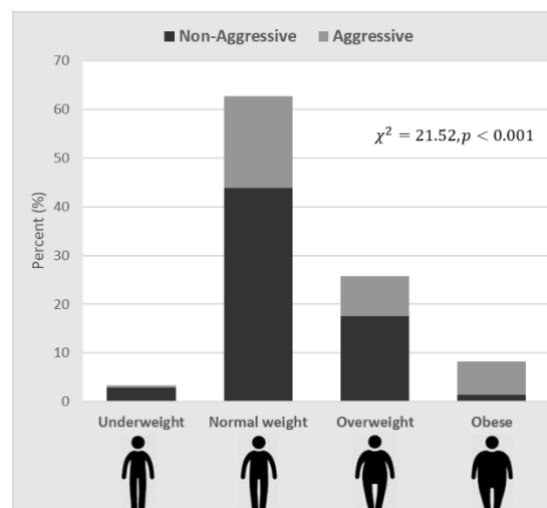
Table 2. Correlation matrix of the research variables (n=218)

Variables	Weight	BMI	FFM	Fat percent	WHR
Aggression	.321**	.303**	.238**	.152*	.165*

Note. BMI: Body mass index; FFM: Fat free mass; WHR: waist-to-hip ratio

Figure 2 displays the relationship between weight status and aggression based on cut off points according to BMI percentile levels. As seen in the figure, there is a significant positive association between weight status and aggression among the children ($p < 0.05$, chi-square test). The odds for aggression increased with increasing weight status. The odds were highest among the children who were obese.

Figure 2. Relationship between weight status and aggression based on cut off points



The outcomes of Pearson's test in investigating the correlation between aggressiveness and body weight factors, body mass index, lean body mass, body fat percentage and the waist-to-hip ratio (WHR) are presented in Table 2. The findings demonstrate that all variables related to body composition possess a significant and direct association with aggressiveness. The strongest correlation is relevant to weight and the weakest correlation is relevant to body fat percentage and WHR.

Table 3. Summary of aggression prediction models

Model	R	R ²	SEE	F	df	Sig.
A. with considering the constant value	.437	.191	10.74	16.85	3	.0001
B. without considering the constant value	.989	.977	11.18	3092.9	3	.0001

Note. R: correlation coefficient; R²: R-squared; SEE: standard error of estimate; F: F-test; df: Degrees of Freedom; Sig: Statistical significance

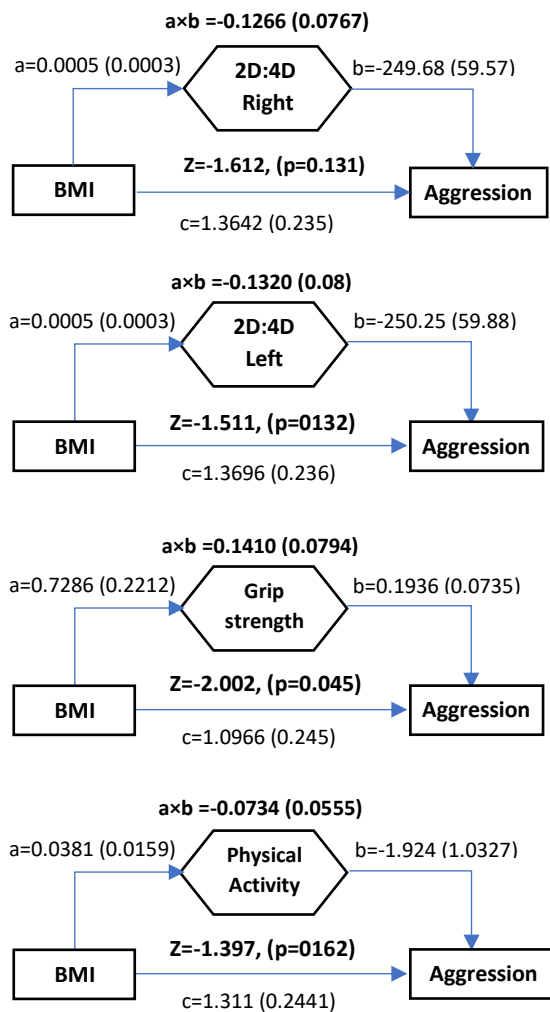
The results of the stepwise regression model are given in Tables 3 and 4. The F test results show the fit of the model A. This model can correctly predict up to 19% of aggression values. Predictive variables in this model included body mass index (BMI), the ratio of the second to the fourth digit of the right hand (2D:4D-R) and fat-free mass (FFM), all of which had a significant effect in the mentioned model ($p \leq 0.05$). Also, the F test results show the fit of the model B (without considering the constant value). This model can correctly predict up to 97% of aggression values. Predictive variables in this model included body mass index (BMI), the ratio of the second to the fourth digit of the left hand (2D:4D-L) and fat percentage, all of which had a significant effect in the mentioned model ($p \leq 0.05$).

Table 4. Selected predictive variables to predict aggression based on stepwise regression

Model	Predictors	B	SE	Beta	t	Sig.
A	constant	261.99	59.55	-	4.4	.000
	BMI	1.23	0.24	0.33	5.12	.000
	2D:4D-R	-227.16	60.13	-0.24	-3.78	.000
	FFM	.14	0.06	0.13	2.05	.041
B	2D:4D-L	25.59	7.85	0.34	3.26	.001
	BMI	2.32	0.41	0.77	5.66	.000
	BFP	-0.38	0.13	-0.13	-3.02	.003

Note. B: Beta coefficient; SE: Standard Error of the Regression; t: t test; Sig: Statistical significance; BMI: Body mass index; FFM: Fat free mass; 2D:4D-R: second-to-fourth digit ratio of right hand; 2D:4D-L: second-to-fourth digit ratio of left hand; BFP: body fat percentage

Figure 3. The path model of the relationship between body mass index and aggression and the mediating role of variables



As can be seen in Figure 3, the mediating role of the variables of 2D:4D of the right and left hands, physical activity and hand grip strength in the relationship between body mass index and aggression have been investigated. According to the results of the Sobel test, among the mediating variables, only hand grip strength has a significant mediating effect on the relationship between body mass index and aggression ($p \leq 0.05$). Z values in the Sobel test in other variables are lower than the critical value.

DISCUSSION

Obesity and overweight are two of the most significant health problems in today's societies, garnering significant attention due to their links with physical and mental health issues. There is an established relationship between obesity/overweight and mental health problems like depression, obsessive-compulsive disorder, bullying victimization, and aggression. However, it remains unclear exactly how this relationship forms and whether manipulating factors within either group could mitigate the effects for individuals in the other group.

The results of the present study showed that aggression is significantly and directly related to weight, body mass index, muscle mass, body fat and WHR. Among the above variables, weight, BMI and muscle mass respectively showed the highest correlation with aggression. These associations are relatively weak, with correlation coefficients ranging from 0.152 to 0.321. These correlation coefficients have been reported to vary in previous studies, depending on factors such as gender, age, and geographical region. The reported ranges of correlation coefficients have been weak to moderate (Tso et al., 2018). The findings of past research in this case are contradictory. The results of a meta-analysis study by Tso et al. (2018) by examining different studies with a large number of participants, a wide range of ages and geographical locations has supported the view that there is a fundamental link between being overweight or obese and being aggressive. In their study, combined effect sizes were highly significant, strengthening evidence that obesity may be a risk factor that contributes specifically to physical aggression (Tso et al., 2018). These evidences highlight the importance of studying the physiological and psychological mechanisms that might help to explain why this occurs. It is possible that being overweight or tall can lead to aggressive behavior in the future, or that a child or adolescent who behaves aggressively may later become overweight or obese (Tso et al., 2018). Results from previous longitudinal studies show that obesity or large body size is a predictor of future physical aggression, and that overweight/obesity precedes physical aggression (Tso et al., 2018). Children with a higher BMI at 12 months were significantly more likely to engage in violent behavior as adults (Ikäheimo et al., 2007). Raine et al (1998) also demonstrate that there is a relationship between body mass index at the age of three and aggression at the age of 11 (Raine, Reynolds, Venables, Mednick, & Farrington, 1998). In contrast, some researchers found evidence that aggression precedes BMI, and Physical aggression at ages 10 and 11 significantly predicts BMI at age 12 (Tremblay et al., 1998). Therefore, the mutual relationship between obesity/overweight and aggression can basically have common determinants. Several theoretical processes may be somehow involved in this

connection. One of the most important models presented is socio-economic theory. Previous studies have shown that having a poor socio-economic status is related to obesity and overweight in children and adolescents (Wu et al., 2015). It is believed that this issue can be related to poor nutrition or malnutrition in less well-off families. On the other hand, some studies have also found a link between low socio-economic status and aggression in childhood (Najman, Clavarino, McGee, Bor, Williams, & Hayatbakhsh, 2010; Santiago, Wadsworth, & Stump, 2011). In these researches, the hypothesis has been proposed that young people who experience chronic family poverty, eventually choose a type of rebellion, delinquent and aggressive behavior due to their inability to join a middle-class section and the mainstream of society. Especially if their social exclusion becomes a more obvious feature of their daily life (Najman et al., 2010). However, this theory is unlikely to fully explain the common association between overweight/obesity and aggression. In the meta-analysis study by Tso et al. (2017), when this variable was controlled, the relationship between overweight/obesity and aggression was still significant. Another theory that has been proposed is that the relationship between being overweight or obese and aggression in young people is an evolutionary tool. The social dominance perspective suggests that, over time, increasing height and weight will increase the use of violence as a strategy for winning social disputes, as well as for securing material resources and gender choice, and sometimes it may be a means to reduce the fame and attractiveness of same-sex couples so that they are less desirable for the opposite sex (Gallup & Wilson, 2009; Tso et al., 2018). An alternative theory is that overweight/obese youth experience more negative peer interactions (in the form of being rejected and/or victimized by peers), which might contribute to later physical aggression. They rely heavily on physical cues to interact and are likely to be influenced by stereotypes associated with such cues (such as obese people being teased, fighting, or selfish and mean) and subsequently behave in the same way (Gunnarsdottir, Njardvik, Olafsdottir, Craighead, & Bjarnason, 2012). In addition to conforming to negative self-stereotypes, overweight individuals may also avoid physical activity to avoid exposure to ridicule and social rejection by others. Therefore, by reducing opportunities for social interaction, they start a vicious cycle. Obese children may be more susceptible to sarcasm and social rejection due to low social competence and social skills (Gunnarsdottir et al., 2012). In future interactions, individuals could acquire knowledge from these exchanges and opt for aggressive conduct towards others, particularly if it is reinforced by helping them achieve certain goals like gaining social standing (Tso et al., 2018). When children transition into adolescence, attaining a prominent social position among their peers becomes significantly crucial, and their sensitivity towards stressors that they perceive as

degrading or shameful intensifies. At the same time, their coping skills undergo significant changes and they acquire emotion-focused coping strategies that may be less adaptive than others (Tso et al., 2018).

The results of the present study showed that in both aggression prediction models, the ratio of 2D:4D was proposed as an effective predictive variable. According to previous research findings, it has been demonstrated that in men, there exists a notable correlation between aggression and a reduced 2D:4D ratio. Bailey and Hard (2005) suggest that this issue is probably due to the role of prenatal testosterone organizer in physical aggression in men (Bailey & Hurd, 2005). But the amount of this relationship is lower than many other physical and physiological factors such as low heart rate and smoking by the mother during pregnancy with aggression (Pratt, Turanovic, & Cullen, 2016). On the other hand, past studies have reported that body mass index (BMI) is significantly associated with lower prenatal testosterone levels and a higher 2D:4D ratio (Manning et al., 2022). However, despite the significant relationship between aggression and 2D:4D ratio in the present study, the 2D:4D ratio of right and left hand did not show an effective mediating role in the relationship between BMI and aggression. One of the reasons for these findings is the strengthening or lack of strengthening of this relationship in some psychological conditions and situations. Kilduff et al. (2013) played a violent video to men and found that those with a lower 2D:4D ratio exhibited more aggressive behavior after watching the video. Interestingly, testosterone levels increased more in men with a lower 2D:4D ratio than men with a higher 2D:4D ratio after playing a violent video (Kilduff, Hopp, Cook, Crewther, & Manning, 2013). Ribeiro et al. (2016) observed a significant increase in strength and moderate increases in testosterone levels, emotional stability, and physical aggression by showing violent tackles to 89 young men. This increase was correlated with a lower 2D:4D ratio in subjects. Interestingly, there was no significant correlation between these indicators and the 2D:4D ratio after playing an ineffective movie (blank screen). Probably, the relationship between these two variables may be due to exposure to prenatal testosterone and self-control mechanism, which can be considered as primary factors of aggression.

In addition to the presented social theories, many psycho-physiological theories have also been proposed in this field. Both being overweight or obese and displaying aggression are linked to prevalent mental health issues like depression and anxiety (Sanders, Han, Baker, & Copley, 2015). Children and teenagers experiencing anxious and depressive symptoms often turn to eating as a means of seeking emotional solace or utilizing stress eating as an emotional defense mechanism or coping strategy (Sanders et al., 2015). According to the researchers, stress-

induced elevation in cortisol levels could potentially play a part in stress-related eating habits. When individuals find themselves amidst high levels of stress, it is quite common for them to turn to delectable foods, particularly those with a high fat and sugar content (often packed with calories), in an attempt to alleviate their unease. Interestingly, chronic stress and depressive symptoms are also associated with sedentary behavior due to a decrease in the level of motivation to participate in physical activities, which may lead to an imbalance between energy intake and energy expenditure and increase the likelihood of overweight or obesity in these people (Tso et al., 2018). The findings of the present study show that the amount of physical activity cannot be considered as a strong and independent variable in predicting aggression. Also, the amount of physical activity cannot be an effective mediating variable in the relationship between obesity and aggression. The findings of past studies are contradictory in this regard. Fite and Vitolano's (2011) study shows a significant and inverse relationship between instrumental aggression and physical activity, but physical activity was not related to reactive aggression. Furthermore, the correlation between active aggression and peer delinquency was influenced by physical activity. Specifically, when engaging in high levels of physical activity, instrumental aggression did not show any association with peer delinquency. However, when involvement in physical activity was minimal, active aggression exhibited a positive relationship with peer delinquency. Therefore, physical activity may be an important factor for moderating the relationship between aggression and other problem behaviors. Another study also shows that physical activity helps to reduce aggressive behaviors (Ubago-Jiménez et al., 2021). Engaging in physical activity is also connected to higher levels of self-efficacy and improved social integration. These skills are crucial in safeguarding individuals against manifestations of depression and anxiety (Tso et al., 2018). Physical activity increases self-efficacy and body satisfaction. Dissatisfaction with the body is an important factor that can mediate between obesity and aggression (Sans et al., 2018).

The findings of this study about muscle strength show interesting results about the prediction of aggression according to muscle strength and its mediating role in the relationship between BMI and aggression. Probably, due to the higher body mass, obese people have higher absolute power than their peers, and based on previous social and psycho-physiological theories, they act violently. Higher absolute power can be a reinforcing factor for a person to use physical aggression and increase the possibility of aggression in the person's subsequent interactions. Interestingly, higher fat-free mass (FFM), which is highly correlated with muscle strength, was also identified as a significant predictor of aggression in this study. Therefore, it can be said

that the weight or body mass index of people who have higher aggression may also have a higher lean mass, which will lead to an increase in the absolute muscle strength of the person. These findings clarify the established relationship between muscle strength, prenatal testosterone and the amount of physical activity based on previous researches. According to a meta-analysis conducted by Pasanen et al. (2022), the results indicate that prenatal testosterone, specifically the ratio between the second and fourth finger, holds the potential to serve as a lasting indicator of well-being. This is achieved by enhancing physical activity levels and bolstering strength. It is likely that prenatal testosterone affects the regulation of several skeletogenic genes responsible for the growth and development of several body systems (eg, musculoskeletal), thereby leading to potential increases in strength. Also, prenatal testosterone may affect muscle strength by influencing physical activity behaviors (Pasanen et al., 2022). In their study, Tomkinson and Tomkinson (2017) discovered a noteworthy correlation between grip strength and the 2D:4D ratio. They took into account various factors like weight, age, and BMI to establish this relationship. They suggested that the level of physical activity of the subjects was probably influential in this connection (Tomkinson & Tomkinson, 2017). This suggests that the possible interaction of prenatal testosterone (lower 2D:4D ratio) and obesity is a potential factor in increasing aggression by increasing muscle strength enhancing factor. On the other hand, the moderating role of physical activity on aggression, which is related to a lower 2D:4D ratio based on past research, can affect and moderate the mediating role of prenatal testosterone in the relationship between obesity and aggression. The relationship between prenatal testosterone and physical activity probably occurs due to more excitement in people with a lower 2D:4D ratio, which itself is caused by the action of some genes effective in neural processing and metabolic functions such as ACE, TPH2 and SNAP25 (Minkwitz et al., 2016). Excitement levels can be a potential genetic factor for problematic behaviors in childhood and adolescence, and engaging in sports activities can be a prominent moderator of this relationship (Wilkinson et al., 2013). Therefore, if the obese child has a lower ratio of 2D:4D, participating in physical activity to moderate the potential aggression of these children seems very necessary.

CONCLUSION

The findings of this research indicate a substantial direct link between aggression and body mass index in children, and adolescent males that may be partially explained by the individual's muscular strength. Factors like prenatal testosterone exposure, obesity, and lean body mass can

forecast aggression in boys to a certain degree. Therefore, focusing efforts on obese children and teenagers who have a lower 2D:4D ratio as a key target group for interventions like attitude changes, social values development, and increasing physical exercise should be considered very crucial. The results of this research could help in needs assessment and planning efforts aimed at reducing aggression in boys as well as determining the need to counsel them with psychologists.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ABSTRACT

ADHD is the most common behavioral disorder in children. Some professional therapeutic treatment (PTT) of ADHD includes also physical exercise (PE) and mindfulness training (MT). In this study we have combined both. The sample included 20 subjects in the experimental (EG) and 19 in the control group (CG). All subjects were ADHD diagnosed boys, aged 10(±1) years. The intervention of the EG used PE and MT, while the CG intervention used unsystematic emotion education. The intervention took place twice a week for 60 minutes over the 3 months. The subjects' expression of ADHD symptoms was measured with the ASEBA CBCL/6-18 protocol (2023). Statistical analyses were calculated using IBM SPSS 25. Differences in the expression of ADHD symptoms between the groups were calculated using the Mann-Whitney rank test for independent samples. There were found no statistically significant differences ($p=0.378$). The short-term effect of the intervention was calculated using a two-factor ANOVA. On the symptom expression measures we found SSD ($p<0.001$) in both groups. There were significantly lower ADHD symptom expression in the EG. The same method was used to determine the long-term intervention effect. On both measures symptoms were a statistically significant ($p<0.001$) lower expressed in the EG. The magnitude of ADHD symptom expression was statistically significant ($p<0.001$) in both groups on both post-intervention measurements, but the symptom magnitude was significantly higher in the CG. Based on the findings, we suggest that such a systematic intervention could be used in modern PTT of children with ADHD.

Keywords: ADHD, intervention, exercise, mindfulness, boys

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EFFECTS OF AN EXERCISE AND MINDFULNESS PROGRAMME ON SYMPTOMS OF ATTENTION DEFICIT HYPERACTIVITY DISORDER IN BOYS AGED 9-11 YEARS

UČINKI PROGRAMA TELESNE VADBE IN ČUJEČNOSTI NA SIMPTOME MOTNJE POZORNOSTI S HIPERAKTIVNOSTJO PRI DEČKIH OD 9 DO 11 LET

IZVLEČEK

Motnja pozornosti s hiperaktivnostjo (ADHD) je najpogostejša vedenjska motnja pri otrocih. Strokovna terapevtska praksa za ADHD vključuje tudi telesno aktivnost (TA) in vadbo čuječnosti (Č). V tej študiji smo združili oboje. Vzorec je vključeval 20 preizkušancev v eksperimentalni skupini (ES) in 19 v kontrolni skupini (KS). Vsi preizkušanci so bili fantje z diagnozo ADHD, stari 10(±1) let. Intervencija v ES je vključevala TA in Č, medtem ko je intervencija v KS vključevala nesistematično izobraževanje o čustvih. Program je potekal dvakrat na teden po 60 minut v obdobju 3 mesecev. Izraženost simptomov ADHD smo merili z vprašalnikom ASEBA CBCL/6-18 (2023). Statistične analize smo izvedli s programom IBM SPSS 25. Razlike v izraženosti simptomov ADHD med skupinami smo izračunali z Mann-Whitney rang testom za neodvisne vzorce, kjer nismo ugotovili statistično značilnih razlik (SZR) ($p=0,378$). Kratek časovni učinek intervencije smo izračunali z dvofaktorsko ANOVO. Pri merjenju izraženosti simptomov smo opazili SZR ($p<0,001$) v obeh skupinah. V ES je bilo izraženost simptomov ADHD bistveno manjša. Enak postopek smo uporabili za ugotavljanje dolgoročnega učinka intervencije. Pri obeh merjenjih so bili simptomi statistično pomembno nižje izraženi v ES ($p<0,001$). Velikost izraženosti simptomov ADHD je bila statistično pomembna ($p<0,001$) v obeh skupinah pri obeh merjenjih po intervenciji, vendar je bila izraženost simptomov bistveno višja v KS. Na podlagi ugotovitev ocenjujemo, da bi se lahko tak sistematičen program uporabil kot ena dodatnih sredstev celostne terapevtske obravnave za otroke z ADHD.

Gljučne besede: ADHD, intervencija, vadba, čuječnost, fantje

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INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is the most common behavioural disorder in children today. According to Thomas et al. (2015), it is expressed in 7.2% of the child population. This disorder mainly affects activities (hyperactivity), behaviour (impulsivity) and the performance of executive tasks (inattention) (CHADD, 2023).

Memarmoghaddam et al. (2016) have shown that executive problem solving performance develops in childhood and adolescence and is related to emotions, behaviour and interactions with the environment. Colomer et al. (2017) explained that ADHD is caused by a dysfunction of the prefrontal lobe of the brain and neurotransmitter transmission, so it seems logical that children with ADHD have difficulties in performing executive tasks (e.g. judging, planning, decision-making).

Ziereis and Jansen (2015) found that a common characteristic of children with ADHD is that they find it difficult to sit still for long periods of time and, without physical activity, focus their attention on what is happening in their surroundings (e.g. listening to explanations, instructions, rules, etc.). In doing so, they experience emotional frustration that influences their behaviour but which they cannot control. Therefore, they also have problems interacting with their environment. At school, this often has a negative impact on their academic performance and their relationships with teachers and peers. The authors also found that, in addition to difficulties in conative, cognitive and social development, children with ADHD also have difficulties in motor development. Compared to their peers, they have less developed muscle strength, balance and coordination, and speed/reactivity. Kim (2018) has also shown that these children (compared to their non-ADHD peers) have poorer muscle strength and balance. He further found that this has an impact on their inappropriate (including unstable) posture. Their poorer coordinated movement (coordination of the whole or parts of the body) in simple motor tasks also affects their poorer complex movement (agility) of the body in space. Therefore, he hypothesised that this is also the reason for the poorer motor and sporting performance than their peers without ADHD symptoms.

Nevertheless, some authors (CHADD, 2023) point out that people with ADHD can be extremely successful not only in sport but also in life if the disorder is recognised, addressed and treated by professionals. Otherwise, they often have problems in childhood and adolescence that have a negative impact on all areas of their life and functioning (family, peer, academic, etc.). If these problems are not recognised (and professionally addressed), they can face serious

problems in later life with their partner, family and other interpersonal relationships, as well as in their professional work. This can lead to various mental disorders (e.g. anxiety, depression), chemical (e.g. alcohol, drug abuse) and non-chemical addictions (e.g. high-risk gambling, obsession with sex), and delinquent and criminal behaviour. It is therefore important that ADHD symptoms are recognised, professionally managed and (if necessary) treated in childhood or early adolescence. This is the only way they can be resolved or adequately controlled (without too much difficulty) by the time the individual reaches adulthood.

The professional therapeutic practice and treatment of ADHD in children is complex and involves several approaches. For mild ADHD, cognitive behavioural therapy (CBT) and adjustments in the school environment are recommended. The main goal of CBT is for the child and parents to recognise, accept and manage the disorder appropriately. Professional collaboration with teachers and school psychological or social services is also very helpful in this respect. In more severe forms of ADHD (and when CBT is not effective), treatment with psychostimulants or medications such as short-acting methylphenidate, extended-release methylphenidate and atomoxetine is most commonly recommended (Pary et al., 2002; Drechsler et al., 2020). Anderluh (2014) stresses that pharmacological treatment of children should only form part of a comprehensive professional management and treatment. In this regard, Wolraich et al. (2019) found that combined treatment with CBT and medication is most effective in children with ADHD. Faraone and Buitelaar had already shown in 2010 that short-term severe ADHD is most effectively alleviated and controlled with medication; long-term severe ADHD is most effectively alleviated and controlled with a combination of CBT and medication. Van Doren et al. (2019) point out that modern professional therapeutic practice and treatment of children with ADHD should focus on short-term appropriate alleviation and long-term control of the disorder. The best results can be expected when all those involved (child, parents and family members, school and out-of-school environment, etc.) are actively involved.

Exercise is purposeful physical activity performed in an organised and planned way to improve physical performance and health. To maintain and improve health, experts primarily recommend exercise for aerobic endurance, strength and flexibility, but also relaxation; for the elderly, they recommend exercise for coordination and balance (WHO, 2022). For children with ADHD, exercise is increasingly being used as an additional means of alleviating the symptoms of ADHD. Den Heijer et al. (2017) found that for children with ADHD, exercise is a safe and effective means of reducing the disorders that occur in children with ADHD.

The effect of exercise programmes on the expression of ADHD symptoms in children has been assessed in a small number of studies (Berwid and Halperin, 2012; Pontifex et al., 2013; Piepmeier et al., 2015; Den Heijer et al., 2017; Arumugam and Parasher, 2019; Chang, Jang, and Ho, 2022), but it is encouraging to see that positive effects have been reported. It is important to note here that they were conducted on small samples that were heterogeneous or without a control group, so their findings should be viewed with some reservation. Berwid and Halperin (2012) found that physical exercise in children with ADHD had a positive effect on the performance of executive tasks due to the stimulation of neurobiological processes. Pontifex et al. (2013) and Piepmeier et al. (2015) also found that a physical exercise programme in children with ADHD had a positive effect on the performance of executive tasks, as reflected in better attention, planning and working memory, and a higher number of correct solutions. Den Heijer et al. (2017), who studied the short- and long-term effects of aerobic endurance training on the incidence of ADHD symptoms in children with ADHD, found that short-term improvements in aerobic endurance were reversed in the long term. However, the short-term improvements in concentration, responsiveness, number of correct solutions to tasks and behaviour were maintained in the long term. Arumugam and Parasher (2019) studied the impact of aerobic endurance training on cognitive abilities and social skills in children with ADHD. They found similar findings - short-term improvement in aerobic endurance and short- and long-term improvement in cognitive abilities and social skills. Chang, Jang and Ho (2022) also found that both short-term and long-term exercise had positive effects on improving motor skills and executive functions and also reducing ADHD symptoms. Based on their research, these authors concluded that physical exercise may be one of the additional means of professional therapeutic treatment and management of children with ADHD.

Mindfulness has recently been increasingly used in professional practice for children with ADHD. In this context, it is defined as a self-monitoring tool for recognising, accepting and responding to ADHD symptoms. Kabat-Zinn (2003) suggests that mindfulness can be developed in a number of ways: relaxed breathing, meditation with observation of thoughts and emotions while at rest (e.g. sitting, lying down) or in movement (e.g. walking, specific movement tasks); or meditation for routine relaxation of muscles or body parts. A small number of studies have also examined the effect of mindfulness training on the incidence of ADHD symptoms in children with ADHD (Haydicky et al., 2015; Behbahani et al., 2018; Chung Chan et al., 2018; Lo et al., 2020). Due to implementation flaws, they have similar limitations to studies that have examined the impact of exercise programmes. Nevertheless, they have also

shown that mindfulness training can have a positive effect on reducing the frequency and intensity of ADHD symptoms. Haydicky et al. (2015) and Chung Chan et al. (2018) found that mindfulness training had a positive effect on the performance of executive tasks in children with ADHD; their attention, working memory and cognitive control improved. Behbahani et al. (2018), who studied the effect of mindfulness training on the frequency and intensity of ADHD symptoms in children with ADHD, found that parents rated their children's ADHD symptoms as less frequent and less intense after training. Parents also reported that their psychological distress was reduced. In a similar study, Chung Chan et al. (2018) found that children with ADHD improved their attention, working memory and behaviour control. Lo et al. (2020) found that for children with ADHD, mindfulness training improved their attention and reduced uncontrolled automatic responses, which were reflected in an inability to control bodily responses (i.e. tics) and behaviour, and marked impulsivity. On the basis of their research, these authors suggest that mindfulness training may be one of the complementary means of professional therapeutic management and treatment of children with ADHD.

We conducted a randomised controlled trial in boys aged 9 to 11 years diagnosed with ADHD to assess the effects of an exercise and mindfulness programme on the incidence of ADHD symptoms.

METHODS

Subjects

A randomised controlled trial involving 39 boys diagnosed with ADHD, with an average age of 10(\pm 1) years, was conducted in the school year 2022/2023. 20 subjects were assigned to the experimental group and 19 to the control group. Inclusion criteria for the study were age ranging from 9 to 11 years and a diagnosis of ADHD without comorbidities (except for specific learning difficulties). The research was conducted in Ljubljana and Maribor. Pharmacological treatment and participation in other organized leisure activities (such as football, basketball and other sports activities) were not associated with ADHD treatment and therefore were not exclusion factors. All subjects participated voluntarily and with the consent of a parent/guardian. The study was approved by the Ethics Committee of the Faculty of Sport, University of Ljubljana (No. 033-14/2021-2) and by the Doctoral Studies Committee of the University of Ljubljana (Decision 2.11. of 7. 6. 2022).

Procedure

Randomisation using sealed envelopes was carried out by an independent person who did not subsequently take part in the study. After baseline measurements, which were taken one week before the start of the intervention, the subjects were randomly divided into experimental and control groups in a 1:1 ratio. The intervention programme of the experimental group was an exercise and mindfulness programme; the sham intervention of the control group was emotion education. Subjects were not informed and did not know which group they were participating in. The intervention programme of the experimental group was led by a Master of science in Kinesiology from the Faculty of Sport, University of Ljubljana, who is also a trainee in Systemic Family Psychotherapy from Sigmund Freud University in Ljubljana. The control group programme was run by the same person, which was intended to further mask the intervention programme to the subjects.

The intervention programme was tailored to boys aged 9 to 11 years. For both groups, the programme ran twice a week for three months; 24 training units were delivered over 12 weeks for both groups. Each training unit lasted 60 minutes. In the experimental group, each training unit was carried out in a planned and systematic way, following a carefully professionalised 12-week intervention programme. In the control group, however, the exercise units were carried out spontaneously and in an unscheduled manner. The exercise intervention programme for the experimental group included simple and complex movement tasks to develop coordination, agility, balance and responsiveness. The teacher's instructions were delivered in a planned and systematic way throughout, with encouragement for auditory and visual perception, allowing the subjects to develop their attention and focus on the tasks. This was integrated in a planned way with the mindfulness intervention programme. In line with the exercise programme, this included simple and complex tasks to develop focus on breath, sight and hearing, and to recognise, accept, understand and regulate emotional experience, which typically manifested as fear, anger and joy. The control group's programme was a spontaneous and unplanned emotion education session in which the subjects listened to, identified and discussed different aspects of emotional experience.

The short-term effect of the exercise and mindfulness programme on ADHD symptom severity in both groups was determined by calculating statistically significant differences between data collected from measurements taken 7 days before the start of the programme (baseline measurements) and 7 days after the end of the programme (endline measurements). The long-

term effect of the exercise and mindfulness programme on ADHD symptom severity was determined by calculating statistically significant differences between data collected at 7 days before the start of the programme (baseline measurements), 3 months after the start of the programme (three-month measurements) and 6 months after the end of the programme (six-month measurements). For both groups, all measurements were made using the ASEBA CBCL/6-18 (2023) assessment scale.

Tools

The Achenbach Assessment Scale for Children and Adolescents - ASEBA (Achenbach, 1991) (CBCL/6-18, TRF/6-18, YSR/11-18) is intended to assess a child's strong areas, adaptation skills, and identify behavioral, emotional and social problems. In our research, we used the assessment scale CBCL/6-18 (ASEBA, 2023), which was filled out by parents or guardians. Always by the same person following the same protocol four times (i.e. at baseline, endline, after 3 and 6 months). The listed scales enable the description of an individual's psychosocial characteristics based on DSM-5 diagnostic criteria (depression, anxiety, somatic problems, ADHD, oppositional-defiant disorder and conduct disorder) (ASEBA, 2023). For the purpose of research, we used a subscale based on the DSM-5 diagnostic criteria: ADHD (ASEBA, 2023). The ASEBA CBCL/6-18 (2023) assessment scale is intended for psychosocial diagnostic purposes and should therefore not be made public. That is why the data collection was participated by an experienced and highly educated psychologist. The degree of expression was scored on a scale where 0 meant that the problem was not expressed or the statement was not valid; 1 meant that the problem was partially expressed or the statement was partially valid; and 2 meant that the problem was fully expressed and the statement was always valid.

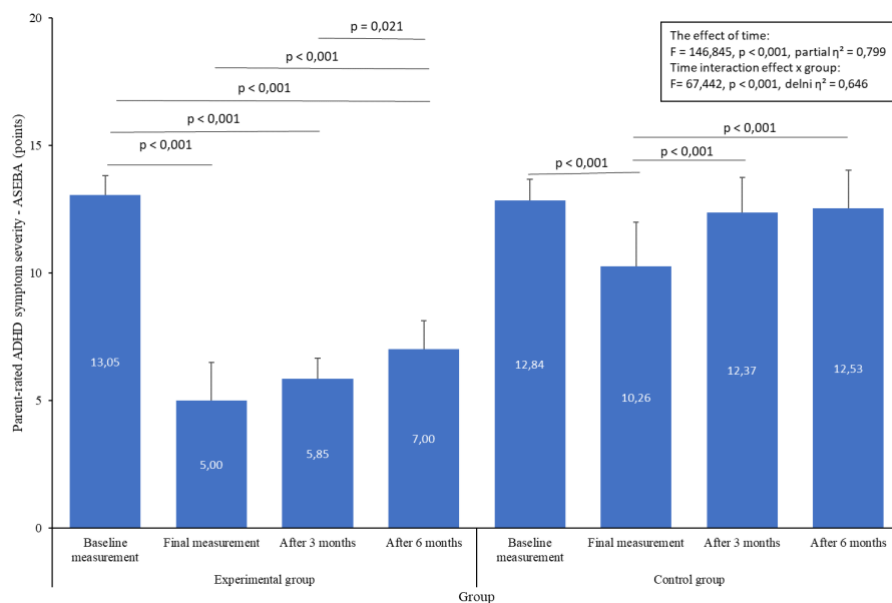
Statistical processing of data

The results were statistically analysed using IBM SPSS 25 (SPSS, Inc., Armonk, NY, USA). The mean and standard deviation of the variables were calculated. Normality of distribution was checked using the Shapiro-Wilk test for the whole sample and separately for the groups (experimental, control). Differences between the groups in age, baseline measurement scores and change at the end of the intervention ($\text{change (\%)} = \frac{\text{final measurements} - \text{baseline measurements}}{\text{initial measurements}} \times 100\%$) were tested using the Mann-Whitney rank t-test for independent samples. As no statistically significant differences were found in the results between the experimental and control groups at baseline, further differences or the effect of the intervention on the expression of ADHD symptoms at repeated measurements (final

measurements, measurements at 3 months, measurements at 6 months) were determined using a two-factor analysis of variance for the repeated measurements. We calculated the effect of time and the effect of the interaction between time of measurements (baseline, endline, 3 months, 6 months) and group (experimental, control). In addition, we used the Bonferroni correction for repeated measures to determine the statistical significance of the differences between the measurements (baseline, endline, 3 months, 6 months) of the experimental and control groups. The magnitude of the effect of the independent variables on the dependent variables for repeated measurements was calculated using the partial eta-squared (η^2). The results were evaluated as statistically significant at the 5% significance level.

RESULTS

Figure 1: Finding statistically significant differences between experimental and control groups in the expression of ADHD symptoms in ASEBA-scored subjects as rated by parents - differences between experimental and control groups



Notes: ASEBA (scores) - expression of ADHD symptoms in children using the ASEBA CBCL/6-18 assessment scale (2023) as scored by parents, ANOVA - F value, p - statistical significance, η^2 - partial eta-squared. In the figure, the numbers in the columns show the expression of ADHD symptoms in the subjects with the mean scores according to the parent's scores on the ASEBA CBCL/6-18 (2023) assessment scale, and the vertical bars show the standard deviation of the parent's scores expressed as points on the same assessment scale.

Figure 1 shows the differences between the experimental and control groups in the expression of ADHD symptoms in subjects with ASEBA scores using the CBCL/6-18 (2023) assessment scale, which was used to obtain parent ratings. This was used to determine the short-term and

long-term effect of the physical exercise and mindfulness programme on the expression of ADHD symptoms in the subjects.

Figure 1 shows that the differences in the expression of ADHD symptoms with mean ASEBA scores between subjects in the experimental ($M=13.05$) and control ($M=12.84$) groups at baseline measurement were not statistically significant ($p=0.378$). This confirms that the groups were evenly matched at baseline, which was also a condition for the continuation of the study.

For the group of subjects studied, differences in ADHD symptom expression with mean ASEBA scores between baseline and endline measurements show statistically significantly lower ADHD symptom expression (-8.05 points, $p<0.001$). Differences in ADHD symptom expression with mean ASEBA scores between baseline and 3-month follow-up measurements also show statistically significantly lower ADHD symptom expression (-7.2 points, $p<0.001$). ADHD symptom expression with mean ASEBA scores between baseline and 3-month follow-up measurements also show statistically significant lower ADHD symptom expression (-7.2 points, $p<0.001$). Similarly, the differences between the baseline measurement and the measurement at 6 months show a similar pattern (-6.05 points, $p < 0.001$). This means that after the intervention, parents rated the subjects' expression of ADHD symptoms statistically significantly lower both in the short term (after 3 months from the start of the intervention) and in the long term (after 3 and 6 months from the end of the intervention), using the mean ASEBA scores. It should be noted, however, that the difference in parents' scores, expressed as the mean ASEBA score, was largest (-8.05 points) between the baseline (13.05 points) and endline (5.00 points) measurements, smaller (-7.2 points) between the baseline measurement and the three-month measurement (5.85 points), and smallest (-6.05 points) between the baseline measurement and the six-month measurement (7.00 points). The data (Figure 1) also show that parents rated the subjects' expression of ADHD symptoms as having a higher mean ASEBA score (7.00 points) at the 6-month follow-up measurement than at the final measurement (5.00 points). Statistical calculations here show a statistically significant increase in the expression of ADHD symptoms ($+2.00$ points, $p < 0.001$). The same is true for the measurement taken three months after the end of the intervention ($+1.15$ points, $p = 0.021$). Interestingly, the data in Figure 1 also show a statistically significant ($p<0.001$) lower expression of ADHD symptoms (baseline measurements - final measurements = -2.58 points) in the control group of subjects after the end of the intervention. However, three months after the end of the intervention (final measurements - measurements at three months = $+2.11$ points), we found a statistically significant ($p<0.001$) increase in the expression of ADHD symptoms. The same applies to the

measurements taken six months after the end of the intervention (final measurements - measurements at six months = +2.27 points, $p < 0.001$).

The effect size of intervention time was statistically significant ($p < 0.001$, partial $\eta^2 = 0.799$). The same was true for the effect size of intervention time and subject group ($p < 0.001$, partial $\eta^2 = 0.646$).

Table 1. Detection of statistically significant differences between experimental and control groups in the extent of parent-rated ADHD symptom expression using ASEBA scores

ASEBA (points)		N	M	SD	S.N.M.	Z	p
Final measurements - Baseline measurements (%)	Experimental group	20	-61,68	11,24	2,51	-5,357	0,000*
	Control group	19	-19,85	13,77	3,16		
Measurements after 3 months - Baseline measurements (%)	Experimental group	20	-55,02	6,90	1,54	-5,361	0,000*
	Control group	19	-3,50	11,18	2,56		
Measurements after 6 months - Baseline measurements (%)	Experimental group	20	-46,25	8,68	1,94	-5,317	0,000*
	Control group	19	-2,12	13,24	3,04		

Notes. ASEBA (scores) - expression of ADHD symptoms in children with ASEBA CBCL/6-18 (2023) according to parents' scores, M - mean of ASEBA scores, SD - standard deviation, S.N.M. - standard error of the mean, Z - test statistic, p - statistical significance.

Table 1 shows the comparison between the two groups of the change in parents' ratings of children's behavioural, emotional and social problems at the end of the intervention, 3 months and 6 months after the end of the intervention. Subjects who implemented exercise combined with mindfulness had statistically significantly greater improvements in parent ratings of children's behavioural, emotional and social problems at the end of the exercise intervention (+41.83%, $p < 0.001$), at 3 months post-intervention (+51.52%, $p < 0.001$), and at 6 months post-intervention (+33.01%, $p < 0.001$), compared to the control group.

DISCUSSION

This study was conducted in boys aged 9-12 years diagnosed with ADHD, examining the short-term and long-term effects of a systematic and planned intervention programme of physical exercise and mindfulness on the expression of parent-rated ADHD symptoms. For this reason, the data obtained cannot be directly compared with similar studies. Overall, the intervention programme of physical exercise and mindfulness had a positive effect. Similar to researchers before us who have studied the effect of exercise (Berwid and Halperin, 2012; Pontifex et al., 2013; Piepmeier et al., 2015; Den Heijer et al., 2017; Arumugam and Parasher, 2019) and those

who have studied the effect of mindfulness (Haydicky et al., 2015; Behbahani et al., 2018; Chung Chan et al, 2018; Lo et al., 2020), we found a reduction in the expression of ADHD symptoms in the subjects after the intervention. From this perspective, we confirmed that an intervention programme of physical exercise and mindfulness can be one of the complementary means of professional therapeutic management and treatment of children with ADHD.

Short-term effects of the intervention programme

The short-term effects of the intervention programme on the expression of parent-rated ADHD symptoms in the subjects were assessed by means of a difference-in-differences analysis between baseline and endline measurements, which was conducted three months after the start of the study in the experimental group, in which the exercise and mindfulness intervention programme was implemented in a planned and systematic way. The analysis showed a statistically significant reduction in the expression of ADHD symptoms. We found that the expression of ADHD symptoms in the subjects was relatively much lower after three months of the programme than before the start of the programme. Interestingly, we found similar results in the control group of subjects, where the emotion education programme was implemented in an unsystematic and unplanned way. The apparent implementation of the programme in the control group was intended to mask the actual implementation of the intervention programme in the experimental group. If we had not implemented the programme in the control group, this would have been quickly revealed in the conversations between the experimental group, as they were peers and socialised in various school and extracurricular activities. The short-term lower expression of ADHD symptoms in the control group at the final measurement (compared to baseline) is thus partly attributed to the placebo (neither parents/guardians nor children knew which group they were in) and partly to the emotion education, where subjects listened to, identified and discussed different aspects of emotional experience. Although we found statistically significantly lower ADHD symptom expression in both groups at the final measurement, the difference in the magnitude of symptom expression between the two groups was statistically significant. We have shown that a planned and systematic exercise and mindfulness programme in the experimental group resulted in a much lower incidence of ADHD symptoms than in the control group. Thus, it can be argued that physical training in coordination, agility, balance and responsiveness, but also mindfulness training to focus on breath, vision and hearing, and to recognise, accept, understand and regulate emotions, had a positive effect, leading to a lower incidence of ADHD symptoms. As we did not determine the effect size or proportion of the effect of exercise and mindfulness training in isolation, we

cannot say which of the two interventions had a greater effect on reducing ADHD symptoms in the subjects. However, we can conclude that the designed physical exercise and mindfulness programme improved attention, self-regulation and calming in the subjects in the experimental group, thereby reducing the severity of ADHD symptoms. Our findings in the positive short-term effects of the programme seem to be in line with researchers who have established the effect of physical exercise programmes in children with ADHD (Den Heijer et al., 2017; Arumugam and Parasher, 2019); as well as mindfulness programmes (Haydicky et al., 2015; Behbahani et al., 2018; Chung Chan et al., 2018; Lo et al., 2020). In our study, we believe that a systematic and planned combination of physical exercise and mindfulness training with simple and complex tasks captured all the core symptoms of ADHD and therefore had a relatively strong and positive effect on them.

Long-term effects of the intervention programme

The long-term effect of the exercise and mindfulness programme in the experimental and control groups was measured at 3 and 6 months after the programme. In the experimental group, both at three and six months after the programme, we found a statistically significant lower expression of ADHD symptoms in the subjects in that group, as assessed by their parents. In the control group, however, the parent-rated ADHD symptom severity was not statistically significant at both 3 and 6 months. Given that the subjects in the experimental group showed the lowest expression of ADHD symptoms at the final measurement and then increased each time at the measurements taken three and six months after the end of the intervention, it can be argued that the effect of the intervention was diminishing over time. It is important to note here that both exercise and mindfulness practice are recognised means of improving mental health and quality of life, but that they only have the desired effect when practised appropriately - several times a week. The fact that both good physical performance and mindfulness decline without adequate exercise has been repeatedly demonstrated. When analysing the magnitude of ADHD symptom expression, we came up with interesting findings, as the difference in magnitude of expression between the experimental and the control group was not greatest on the final measurements (after 3 months of the programme), but on the measurements after 3 months of the intervention. At the 6-month follow-up, the difference was statistically significant, but had already decreased significantly. The decline in results is attributed to the diminishing impact of the physical activity and mindfulness programme. As expected, the effect of the programme diminishes with distance from the end of the programme, but nevertheless, compared to before the programme, it still has an effect and an impact on the magnitude of

ADHD symptom expression. It is important to note that six months after the end of the programme, the expression of ADHD symptoms in the experimental group was still significantly lower than before the programme. Moreover, at the beginning of the study, all subjects were classified as symptomatic, but subsequently the subjects in the experimental group achieved normative scores on all follow-up measures after the physical activity and mindfulness programme. This means that the control group remained symptomatic throughout the school year, while the experimental group reduced the severity of these symptoms to normative values. Achenbach and Rescorla (2003) stated that children whose ADHD symptom expression reaches normative values with the CBCL/6-18 (2023) assessment scale scores do not need ongoing professional help. However, children whose scores place them in the clinical treatment range usually have high symptom severity and require ongoing professional help to monitor their mental health. Even when considering the findings of the long-term effects of our intervention programme, we stress that they cannot be directly compared with the findings of previous research. However, we can argue in accordance with them that both physical exercise (Berwid and Halperin, 2012; Pontifex et al., 2013; Piepmeier et al., 2015; Den Heijer et al., 2017; Arumugam and Parasher, 2019; Chang, Jang, and Ho, 2022) and mindfulness training (Haydicky et al., 2015; Behbahani et al., 2018; Chung Chan et al., 2018; Lo et al., 2020); or better still their combination, serves as an additional means of modern - comprehensive professional therapeutic treatment and management of children with ADHD.

CONCLUSION

The findings suggest that exercise can play an important role in managing the symptoms of ADHD, improving the overall well-being of children with the disorder. A number of studies have shown that regular physical exercise can have a positive impact on reducing ADHD symptoms, including increased attention, reduced hyperactivity and impulsivity, and improved cognitive function. We hypothesise that physical exercise may increase levels of neurotransmitters such as dopamine, which is associated with attention in executive tasks. It is essential that exercise intervention is planned and systematic, and that it is performed consistently. The duration of intervention programs with physical activity, in which positive effects were reported, was different (1 to 34 months) (Donnelly et al. (2016). In our case, when the program lasted twice a week for three months, we found an improvement in the subjects' ability to maintain attention and concentration.

We also hypothesise that physical exercise can help to release children's hyperactivity and mental tension, thereby reducing their impulsivity. We conclude that regular physical exercise can help balance energy levels and improve self-control of emotions and behaviour. This is probably because exercise increases blood flow to the brain, which in turn provides the cells with an abundant supply of oxygen and energy. This is thought to improve cognitive function, which is important for remembering, learning and performing executive tasks. It may also affect the development of brain structures related to these functions in children. Exercise is also known to release endorphins, which are natural 'happiness hormones' and are credited with reducing mental stress and anxiety. Therefore, with regular exercise, we can also expect to experience improved mood and general well-being. We recommend that children with ADHD get at least 60 minutes of physical exercise a day, which is in line with WHO recommendations (2022). Further benefits can be expected when exercise is planned and systematic, and led by trained professionals who also take into account children's individual interests and motivations, which can further influence their well-being and satisfaction.

Mindfulness training in children with ADHD is reported by some research to be an important additional means of managing ADHD symptoms. Findings suggest it can help improve the longer-term maintenance of adequate concentration, attention and focus when performing executive tasks. We conclude that in children, deliberately and systematically focusing attention on the present moment may help to reduce ADHD symptoms and redirect their attention to the performance of current tasks. In line with our findings, however, similarly to exercise, we stress that a positive effect can only be expected with consistent exercise - at least twice a week for at least three months. We hypothesise that it is during this period that children increase their ability to control and act on disturbing thoughts and feelings that trigger uncontrolled impulsive behaviour. It is also important to reduce the critical response of the environment (e.g. parents, teachers, peers), which can trigger further frustration in children with ADHD symptoms. Therefore, we believe that mindfulness training can be a good tool to reduce psychological distress and anxiety. Children with ADHD most often experience this precisely because they do not recognise and manage their ADHD symptoms. We conclude that through consistent mindfulness training, they can also develop greater mental, physical and emotional control, which has the effect of reducing the occurrence of anger, fear and aggression. In our case, this was achieved through simple and complex mindfulness tasks focusing on breath, sight and hearing, which clearly had an impact on recognising, accepting, understanding and regulating their emotional experience. However, we assume that similar results can be achieved through

meditation, breathing exercises and other means. Similarly to physical exercise, mindfulness training for children with ADHD emphasises that the desired - positive - effects of reducing the expression of symptoms can only be expected with planned and systematic training, led by trained professionals who also take into account the children's individual interests and motivation, and can thus further influence their relaxation, well-being and satisfaction.

The program contributed to a lower expression of ADHD symptoms, but this does not mean that they are no longer diagnosed with ADHD.

Based on our findings, we believe that physical exercise and mindfulness training can be one of the complementary means of modern - professional therapeutic treatment of children with ADHD.

Shortcomings and limitations

The biggest drawback of the survey was the relatively small sample of male subjects, aged 9-11 years. We believe that future research in children diagnosed with ADHD would benefit from a larger sample including both sexes. We therefore suggest that a future study with three experimental groups and one control group be carried out. One experimental group should implement the exercise programme, the other the mindfulness programme, and the third the exercise and mindfulness programme. It would probably be more appropriate to use specifically designed scales for the ADHD assessments in future research to measure the expression of ADHD symptoms in children. While there are three main types of ADHD (predominantly inattentive presentation, predominantly hyperactive/impulsive presentation and combined presentation), with our research we were unable to identify differences between them with the rating scale CBCL/6-18 (ASEBA, 2023). However, this was not possible due to the small sample size. It should be also taken into account that despite the fact that our research found that the intervention program had a positive effect on the lower expression of ADHD symptoms, this does not mean that the change was clinically significant for the participants (and they no longer have symptoms or a diagnosis of ADHD).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ELEVATING ATHLETIC PERFORMANCE: THE BODY TECHNIQUE PROTOCOL'S EFFECT ON VITALITY AND RESPIRATORY WELLNESS

IZBOLJŠANJE ŠPORTNEGA NASTOPA: UČINEK PROTOKOLA *BODY TEHNIKE* NA DVIG VITALNOSTI IN DIHALNEGA ZDRAVJA

ABSTRACT

Engaging in regular exercise and sports can inadvertently lead to habitual movement patterns, restricting specific body parts' range of motion and diminishing joint elasticity. This decline in muscle flexibility impacts energy levels during physical activities, thus affecting overall vitality. Subjective Vitality State (SVS) captures the essence of feeling alive, reflecting an individual's energy reserves. The study involved 36 healthy young athletes aged 22.48 ± 3.54 years, categorized into control and treatment groups. The treatment group followed a novel Body Technique exercise protocol (BT), while the control group adhered to a familiar conditioning protocol. Both protocols included five exercises targeting various muscle groups. The study focused on subjective vitality, perceived intensity load, and chest girth differences during breathing. Analysis of subjective vitality change within groups showed no significant difference for the control group before and after treatment ($p=0.44$), while the treatment group exhibited significantly higher subjective vitality after BT exercises ($p=0.00$). Significant differences were found in the "exhale-inhale" variable for the treatment group before and after treatment ($p=0.00$), but not for the control group ($p=0.15$). BT protocol demonstrated superior effects on SVS and chest girth, highlighting the significance of innovative, unconventional exercise in sports. By addressing concerns such as fatigue and injury, BT protocol may offer the prospect of better results in forthcoming training sessions. The study encourages a paradigm shift in exercise approaches, emphasizing conscious intervention to address novel movement patterns and enhance well-being in athletes.

Keywords: vitality, holistic, exercise, movement, mobility

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IZVLEČEK

Ukvarjanje z redno vadbo in športom lahko nehoti vodi do ponavljajočih vzorcev gibanja, omejuje obseg gibanja določenih delov telesa in zmanjšuje elastičnost sklepov. Upad prožnosti mišic vpliva na raven energije med telesno aktivnostjo in posledično na splošno vitalnost. Subjektivno vitalno stanje (SVS) predstavlja občutek "biti živ" in odraža posameznikove zaloge energije. V raziskavo smo vključili 36 zdravih mladih športnikov, starih povprečno 22.48 ± 3.54 let, razvrščenih v kontrolno in eksperimentalno skupino. Slednja je sledila novemu protokolu vadbe *Body Tehnike* (BT), medtem ko se je kontrolna skupina držala že znanega protokola telesne aktivnosti. Oba protokola sta vključevala pet vaj za različne ciljne mišične skupine. Raziskava se je osredotočila na subjektivno vitalnost, zaznane intenzivnost obremenitve in razlike v obsegu prsnega koša med dihanjem. Analiza subjektivne spremembe vitalnosti znotraj skupin ni pokazala pomembnih razlik za kontrolno skupino pred in po vadbi ($p=0,44$), medtem ko je eksperimentalna skupina pokazala znatno večjo subjektivno vitalnost po vadbi BT ($p=0,00$). Pomembne razlike so bile ugotovljene v spremenljivki "izdih-vdih" v eksperimentalni skupini pred in po vadbi BT ($p = 0,00$), ne pa tudi v kontrolni skupini ($p = 0,15$). Protokol BT je pokazal boljše učinke na SVS in prsni obseg ter poudaril pomen inovativne, nekonvencionalne vadbe v športu. Z obravnavo izzivov, kot sta utrujenost in poškodba, lahko BT protokol obeta izboljšanje rezultatov v prihodnjih treningih. Študija spodbuja spremembo paradigme v vadbenih pristopih, poudarjajoč zavestno intervencijo za obravnavo novih gibalnih vzorcev ter izboljšanje dobrobiti športnikov.

Ključne besede: vitalnost, celostno, vadba, gibanje, mobilnost

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INTRODUCTION

Exercise is a structured and repetitive activity designed to enhance fitness and is widely promoted for its health benefits, including a reduced risk of cardiometabolic diseases and certain cancers (Febbraio, 2017). Often unconscious and overlooked, breathing is a central aspect of our whole being and is one of our most vital functions (Clifton Smith and Rowley, 2011). This cyclic exchange of gasses is responsible for maintaining tissue oxygenation and promoting a balanced state inside the body, also known as homeostasis (Jelinčić, Van Diest, Torta and von Leupoldt, 2021). The full functional movement of the diaphragm and external intercostal muscles relies on the elasticity and balanced alternation of concentric and eccentric contractions (Tong and Fu, 2006). Hence, chest expansion training becomes crucial for optimal respiratory function and condition, especially in the context of injury and illness, where focused breathing exercises are essential to strengthen muscles for optimal lung function at rest (Drigas and Matsea, 2022).

Research by Ohya, Hagiwara, and Suzuki (2015) suggests that incorporating inspiratory muscle warm-up exercises into regular training sessions and warm-ups may not be crucial for optimal high-intensity exercise performance. However, previous studies have shown that adding inspiratory muscle warm-ups to the overall routine enhances exercise performance. This specialized warm-up has been associated with improved inspiratory muscle function, reduced perception of breathlessness, and lower lactate concentrations during exercise (Lin et al., 2007; Lomax et al., 2011; Tong and Fu, 2006; Volianitis et al., 2001).

In the realm of respiratory training, the synergistic activation of trunk muscles during the expiratory phase and expiratory muscle training have been found to reduce feelings of respiratory fatigue in normal subjects (Drigas and Matsea, 2022). Important expiratory muscles include the rectus abdominis, internal intercostal muscles, latissimus dorsi, and serratus posterior-anterior (Hall and Guyton, 2012).

Contemporary sports pose significant daily challenges for athletes and sports professionals. As sports' popularity increases, athletes become more aware of the substantial time and energy investment required to maintain peak performance levels (Kovačević, 2020). Drawing from the experiential knowledge of Body Technique (BT) trainers, BT exercises aim to introduce new neuromuscular patterns to the subconscious, addressing issues such as fatigue, injury, and excessive training strain (Jagodić Rukavina, 2019). By balancing concentric and eccentric contractions of the diaphragm in three-dimensional movements of the spine and chest, BT

exercises may accelerate regenerative mechanisms, homeostasis, and states of subjective vitality (SVS) in athletes.

Shifting the exercise emphasis from traditional metrics to more sophisticated, mindful movement patterns highlights the importance of quality and the mind-body connection in BT. This approach encourages practitioners to focus on experiences, sensations, inner awareness, posture, and breath, rather than solely relying on quantitative measures. Integrating both aspects into training sessions promotes a more holistic approach to sports performance.

BT exercises primarily focus on spinal movement and slow, fluent breathing. Conditioning exercises within BT emphasize large and superficial muscle strengthening with increased demands on breathing and heartbeat. Recent research by Strohacker, Keegan, Beaumont, and Zakrajsek (2021) in exercise prescription and periodization emphasizes the significance of subjective experience in both medium- and long-term monitoring and acute experiences. The Borg rating of perceived exertion (RPE) is one method employed to measure exercise intensity (Borg, 1998).

Subjective readiness, considering pre-exercise mental and physical states, plays a crucial role in determining how exercise is experienced and can be modified based on training goals (Strohacker et al., 2021). Subjective vitality (SVS), an essential aspect of Eudaimon's well-being, reflects a person's sense of feeling alive and awake with energy at their disposal (Ryan and Deci, 2001). Ryan and Frederick (1997) developed a scale assessing current SVS, negatively related to physical pain and positively to the amount of support in a given situation (Nix et al., 1999). SVS addresses the ideal state of psychological well-being and serves as a reliable measure of psychological health across diverse groups.

In a study examining subjective responses (SVS and RPE variables) and an objective response (chest girth in inspiration and expiration), athletes, with their adaptability to new movement patterns, are ideal participants. The hypothesis is that athletes engaging in BT exercises will report higher SVS scores. Although the perceived intensity of exercises may be similar among athletes, variations in chest girth are expected due to specific spinal flexibility, well-coordinated muscle contractions, and slower breathing rhythms in the BT protocol (Wright et al., 2016).

The study aims to address gaps in existing literature related to innovative exercise protocols and their impact on athletes' well-being. The potential alleviation of fatigue and overtraining through BT protocols holds practical implications for the sports community, providing effective strategies for managing physical and mental stress. Encouraging holistic thinking in the sports

process, the study emphasizes subtle, mind-body connected training protocols that could enhance subjective vitality and condition athletes' respiratory muscles during sports training, optimizing overall training and recovery effectiveness.

METHODS

Participants

In this randomized experimental study forty athletes from different sports fields were included. The athletes had training once or twice daily, with regular tournament events. They were recruited from one sports Centre in Karlovac, Croatia. The study was performed in two days during two weeks, at the beginning of January 2022. All athletes were between 18 and 26 years old, with an average age of 22 years. After the evaluation of the current psychophysical state (physical condition, body temperature, and respiratory rate), injuries, age, employment status, and presence of any post-COVID-19 symptoms, four athletes were excluded due to exhaustion, higher temperature, and injury. So, in total, 36 athletes participated in this study, 8 women and 28 men. All participants were informed about the study but not about its exact purpose, and written consent was obtained from every participant before admission into the study. Initial and final measurements were conducted by two kinesiologists. This study was designed in accordance with the Helsinki–Tokyo Declaration and was authorized by the National Committee for Scientific Work and Ethics ([No. 105/2023](#)).

Exercise protocols

Before the measurements, all participants signed a declaration of voluntary participation and allowed the use of the results for research purposes. The participants were divided into two groups, the control group and the treatment group by randomized procedure (blind drawing). Each group consisted of 18 participants. Each group had a demonstrator who performed the exercise protocol received before. Demonstrators showed the exercises to each group at the same time, place, and conditions of the experiment.

The exercise protocol for the treatment group consisted of BT (Jagodić Rukavina, 2019) newly developed kinesiological activity: „accordion“, „fan“, „skier“, „catapult“ and „agitator“, while the control group performed exercises from the basic conditioning training and fitness field mostly found in athletes' training regime: forward lunge, front plank, lateral toe tap, windshield wipe, crisscross oblique (Contreras, 2013; Lademann, 2019). Both exercise protocols consisted

of 5 exercises. Each exercise (from 1-5), performed in both groups had a similar topographic impact, and muscular dominance, although they were very different from the observer's point of view. The first set of exercises affected dominantly muscles of the trunk, the second set, muscles of the legs, the third set, muscles of the shoulder girdle and trunk, the fourth set, muscles of the hips, and the fifth set of exercises impacted mostly muscles of the spine. All exercises were performed for 90 seconds, after 30 seconds of explanation. The treatment and control groups performed their task simultaneously.

Questionnaires

Before, as well as after completing the exercise protocol, all participants completed the initial Subjective vitality scale (SVS) questionnaire. The SVS (Ryan and Frederick, 1997) is a 7-item self-report instrument that is designed to assess feelings of energy and vitality. Cronbach's alphas for the scale were 0,84 and 0,86, with test-retest reliabilities exceeding 0,70. In this experiment, we used an updated scale of 6 items. A questionnaire with the 6-item model consisted of items 1, 3, 4, 5, 6, and 7 by excluding a negatively worded item (Item 2: "I don't feel very energetic") according to Bostic, Rubio, and Hood (2000).

The Borg Scale, specifically the revised category-ratio scale ranging from 0 to 10, was employed to assess the participants' rate of perceived exertion (RPE). This scale is a recognized and dependable method for monitoring and managing exercise intensity. Its utilization allows individuals to provide subjective ratings of their exertion levels during physical activity. Participants received clear instructions on how to complete the questionnaire, as outlined by previous studies (Whaley et al., 1997; Borg, 1998). Following the conclusion of each exercise session, every participant filled out the Borg scale to indicate their RPE.

Chest girth

All participants underwent the anthropometric measurement - chest girth in expiration and inspiration, before and after completing the exercise protocol. The girth measurement is a method to analyse the changes in body dimensions over time. Girths are circumference measures at standard anatomical sites around the body. It is measured with a flexible measuring tape and a pen for marking the results on the body. Reliability depends on the examiner who should not put the tape too tight or too loose around the chest girth with arms resting aside. It must be flat on the skin, and horizontal. The examiner must focus on the same tension in measuring each participant standing in a normal erect posture. The measurement is taken from under the axilla (4 rib level) and around the chest, passing by the sternum at the level of the

nipple. Measurement reading is taken from the middle position of the sternum. The first measure is in the expiration phase and the second is in the inspiration phase. The measurement was performed only once. The examiner is cueing the participants to be as big as possible, during inhalation and as small as possible during exhalation, without encouraging them to expand their chest or belly.

Statistical analysis

All data analyses were conducted using SPSS version 25. Basic statistical parameters were calculated for all variables. The normality of the distribution was verified by the Shapiro-Wilk test and the homogeneity of the variance by the Leven test.

In order to check the difference between the treatment and control group in a subjective vitality scale, two t-tests (independent samples) were conducted, one for the results before the treatment and the other for the results after the treatment. To check if there are significant differences in results on a subjective vitality scale before and after the treatment for each group (treatment and control group), two t-tests (dependent samples) were conducted. To check if there was a difference in the chest girth “exhale-inhale” difference between the treatment and control groups, two t-tests for independent samples were performed, one for the first measurement point and the other for the second measurement point. Additional two t-tests for dependent samples were performed, to check if there are differences in results before and after the treatment in each group. To investigate the impact of exercises on participants from their subjective rating on the level of exertion (RPE) while performing them, another t-test for independent samples was conducted. Statistical significance was confirmed at the level of 5% probability of error ($p \leq 0.05$).

RESULTS

Table 1 presents descriptive data pertaining to participants in both the control and treatment groups. The data includes measurements of the difference between exhalation and inhalation in centimetres at the first and second measurement points, as well as subjective assessments of perceived effort (RPE – evaluation from 1-10) and vitality index (SVS – evaluation from 1-7) at the same measurement points.

Table 1. Descriptive statistics

	Treatment group		Control group	
	(N = 18)		(N = 18)	
	<i>M</i> ₁	<i>SD</i> ₁	<i>M</i> ₂	<i>SD</i> ₂
Exhale-inhale difference (before treatment)	5.78	1.52	6.56	2.01
Exhale-inhale difference (after treatment)	7.33	2.14	7.39	2.42
Subjective assessment of perceived effort	4.44	1.09	4.66	1.80
Vitality index (before treatment)	4.57	0.23	4.26	1.14
Vitality index (after treatment)	5.11	0.95	4.42	1.60

In SVS data show the best subjective vitality score in the treatment group after the exercise protocol. Comparing the variable subjective assessment of observed effort (RPE) after each exercise in both groups, results show a minimal difference. The chest girth is obviously higher after the treatment in both groups but there is much bigger diversity compared to the first and second measurements in the treatment group.

Subjective vitality scale

To analyse how participants responded on? A subjective vitality scale SVS in two different types of exercises, the difference between the two groups before and after the treatment was analysed. In order to address the first research question, two independent samples t-tests were conducted. One for the vitality index variable at the first measurement point before treatment, and another for the vitality index variable at the second measurement point, with group membership (treatment/control) serving as the independent variable (Table 2).

Table 2. Results of the t-test for the dependent variables Vitality, “exhale-inhale” in first and second points of measurement, and subjective assessment of perceived effort level considering membership in the treatment or control group (N=36).

	<i>T</i>	<i>df</i>	<i>p</i>
Vitality – first point of measurement	0.76	34	0.45
Vitality – second point of measurement	1.58	34	0.23
„Exhale-inhale “– first point of measurement	0.13	34	0.19
„Exhale-inhale “– second point of measurement	0.07	34	0.94
Subjective assessment of perceived effort level	0.47	34	0.64

Notes. No statistically significant difference in the level of vitality was detected between treatment and control groups either at the first measurement point, before the exercise ($p=.45$), or after exercise ($p=.23$).

To examine whether there is a difference in the variable "exhalation-inhalation difference" between the treatment and control groups, we conducted two independent samples t-tests—one for the first measurement point and another for the second measurement point (Table 2), explained in the subsection of chest girth.

The Analysis of change in the level of subjective vitality and difference within analysed groups (analysed with dependent t-test) before and after the exercise treatment showed no statistically significant difference in the level of vitality for the control group before and after treatment ($p=.44$). Regarding the treatment group, the level of subjective vitality was significantly higher ($p=.00$) after the BT exercises (Table 3).

Table 3. T-test results of variables Vitality and “exhale-inhale” before and after the exercise treatment for both groups (N=36).

	<i>t</i>	<i>df</i>	<i>p</i>
Vitality - Control group	-0.76	17	0.44
Vitality - Treatment group	-3.44	17	0.00*
"exhale-inhale" - Control group	-1.52	17	0.15
"exhale-inhale" - Treatment group	-6.10	17	0.00*

Chest girth

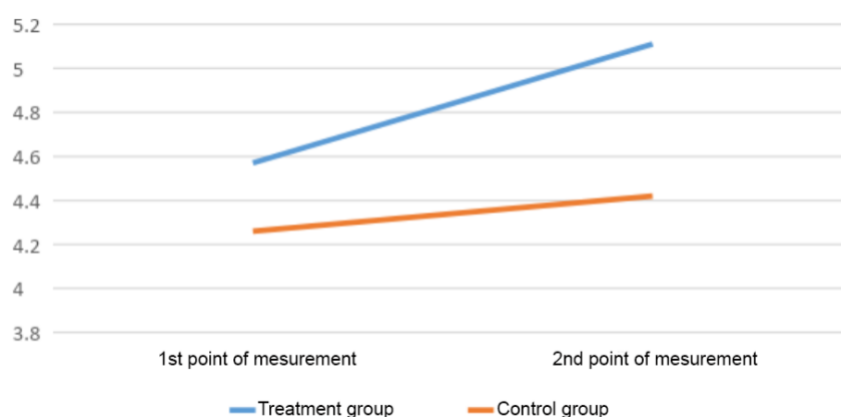
To analyse the changes in chest dimensions before and after the exercise treatment, we compared the difference in chest girth between the expiration and inspiration phase. To check if there was a difference in the chest girth “exhale-inhale” difference between the treatment and control groups, we performed two t-tests for independent samples, one for the first measurement point and the other for the second measurement point (Table 2).

The results of the t-test showed no statistically significant difference in the “exhale-inhale” difference between the treatment and control groups at the first measurement point ($p=0,19$). Also, there was no statistically significant difference ($p=0,94$) (Table 2) for the “exhale-inhale” variable between the treatment and control groups for the exhale-inhale variable at the second measurement point (after the exercise treatment).

Additionally, with the t-test for the dependent samples, a difference in the variable chest girth “exhale-inhale” in the first and second measurement points for participants within control and treatment groups was also investigated. In addition, a statistically significant difference for the variable “exhale-inhale” in the sample of the treatment group before and after treatment ($p=0,00$) was detected. Higher results for the “exhale-inhale” variable indicate greater respiratory muscle strength after treatment. No statistically significant difference was found for the control group ($p=0,15$) (Table 3).

Display of results on the vitality scale for the treatment and control group before (1st measurement point) and after treatment (2nd measurement point) is shown on Figure 1. The blue-coloured line shows the treatment group, while the orange line represents the control group. The blue coloured line indicates that the treatment group tends to show higher growth in results compared to the orange line of the control group.

Figure 1. Vitality index results for treatment and control groups – before and after treatment.



Subjective assessment of observed effort

To investigate the impact of exercises on participants, considering their subjective assessment of exertion levels during performance, we analysed their Rating of Perceived Exertion (RPE) and conducted a comparative analysis between the treatment and control groups. The findings revealed no statistically significant difference in RPE between the examined groups ($p = 0.64$), as illustrated in Table 2.

DISCUSSION

The everyday athlete's training starts with different intrinsic loads (energy levels, emotions, stress, quality of sleep, gut health, relationships, etc.). According to Hamsta-Wright, Huxel Bliven and Napier (2021), „we need more clinicians to subjectively assess cumulative risk profiles in athletes “, and take holistic and integrative approaches to adequately analyse and determine an individual's specific capacity. To our knowledge, this is the first study investigating differences in two different types of exercise for athletes in the level of subjective vitality SVS. The observed changes in SVS after the short BT intervention can be attributed to the comprehensive and quality-centred nature of the exercises. These exercises engage athletes both physically and mentally, leading to improvements in their subjective sense of vitality. Balanced exposure to load for spine and joints in BT exercises attracts body-mind connections which are not common in sports training. A holistic approach looks at an athlete as a whole, meaning it would study an athlete's behaviour, well-being levels, and life habits simultaneously examining his physical function and performance. A holistic approach to training consists of graded and balanced exposure to load in movement considering the individual capacity (Esculier, et al., 2020). For that, educated and open-minded coaching behaviour is needed. Such an approach is associated with various mental well-being outcomes, positive affect, vitality and motivation, life satisfaction, resilience, and self-concept, as well as prosocial behaviour towards teammates (Barrio, et al., 2021). Clinicians also oversee particular importance in continuously educating athletes, so they would be aware of their body's cues and thus they could react and understand their mind-body connection better. Incorporating questionnaires for self-analysing inner motivation, satisfaction, feelings, vitality levels, the intensity of training, *etc.* could help raise awareness both for athletes and for coaches. In this study, we used SVS and Borgs questionnaires to identify qualitative and intrinsic states from athletes during one training session.

The primary aim of this study was to highlight the potential impact of incorporating BT into sports routines, with a focus on enhancing the mind-body connection. By integrating BT into warm-up and cool-down sessions, athletes could potentially enhance their sports performance, prevent injuries, and elevate their overall life satisfaction by promoting mental health and mindfulness. In our study, the vitality variable data showed the best subjective vitality score in the treatment group after the BT exercise protocol. We did not find similar investigations to compare our results with but based on our results, after performing BT exercises, participants had significantly higher levels of SVS. It could be because it was rather new in both inner focus and movement patterning. Having them coordinate fluent movement in three-dimensional spine mobility with breathing, their inner perception probably raised which helps mind-body connection. Additionally, statistically significant higher results for the "exhale-inhale" variable in the treatment group indicate greater respiratory muscle strength and chest mobility after the treatment. Juric, Labor, and Plavec (2020) investigated a group of professional athletes and reported that inspiratory muscle strength (with some other variables) significantly affects the performance of these athletes in the part of most exclusively anaerobic metabolism and it should be tested and trained systematically. The physiotherapeutic breathing exercise program was found to be just as effective as yoga and Pilates in enhancing spinal mobility and rectifying posture issues among healthy young women. This suggests that practicing coordinated breathing exercises while moving the spine and chest in three dimensions, particularly in a seated position, may facilitate the release of deep tissue tension and potentially unlock small joints in the thoracic spine and rib cage (Csepregi et al., 2022). It enables inspiratory muscles for higher eccentric and concentric contractions throughout two phases of BT exercises. For a better understanding, the BT exercise can be divided into two phases. The first phase of inhalation with a maximum increase in mobility and the second phase of exhalation with emphasis on stability and inner strength (Jagodić Rukavina, 2004).

It is important to note that examining differences between the two types of exercise protocols was in limited time for only five exercises. Each exercise lasted for 90 seconds. Given this, the study aims to assess the potential efficacy of the BT protocol as a recovery strategy. This holds significance, especially in high-performance sports where athletes often face inadequate recovery and rest periods, potentially leading to the accumulation of tension, fatigue, and reduced vitality. Engaging BT protocol for not more than 10 min per training could be of help without disturbing their schedule. We are aware that physical functioning and performance directly determine the competitive level of athletes. Therefore, technology today enables us

through real-time monitoring of athletes' functional status and their positions in the training process and targeted determination of guidance programs, which is very important means of scientific training today (Biao, et al., 2020). However, we would like to emphasize a concern about the separation of the mind from the body in sports in general. The body functions according to patterns it has learned during life and sport. Until an injury or limitation occurs, that habitual movement serves well. To become faster, stronger, more flexible, less prone to injury, and better-equipped athletes, training should provide complementary body experiences not just monitoring systems based on technology. Amy and Rick Lademann (2018) assert that engaging in repetitive actions in sports, which may not be the most optimal movement pattern, can potentially lead to overuse injuries, strains, and more severe issues. If left unresolved, these problems have the potential to result in long-term complications affecting muscles, joints, tissues, and nerves. Hence, beyond the inclusion of real-time data for physical performance in a standard training program, coaching ought to furnish a comprehensive array of tools, motivational strategies, knowledge, and adaptability to facilitate an athlete's improvement across all potential skills and capabilities.

As our clinical experience shows, BT exercises are more focused on spinal movement as bodies centre in one continual motion - the flow that brings knowledge and versatility to training. With deep and slow fluent breathing through concentric and eccentric phases in each exercise, it emphasizes that the movement begins at the centre and sequences out (Jagodić Rukavina, 2019). Exercises presented here are all in seated positions and are not habitual. Their main focus is to bring awareness through mobility and stability to the spine, chest, shoulders, and hips.

In terms of conditioning, traditional exercises focused on muscle strengthening and increasing heart rate and breathing rate typically provide athletes with a solid training intensity. However, the BT approach aims to go beyond this by enhancing and enriching the training experience. Following BT exercises, participants often reported gaining new insights or perspectives on their training regimen. Every new insight is a result of an afferent-efferent neurological bridge that brings more energy connections and neuro-muscular pathways to athletes' self-knowledge (Hartley, 1995).

Strengths and limitations

The study had a limited number of training sessions, with each group participating in only two sessions. This constraint could be addressed by increasing the number of training sessions in future studies. Additionally, the study's sample size was relatively small, with predominantly

male participants, which may limit the generalizability of the findings to other populations. From our clinical experience, male recreational participants of BT execute the exercises with more difficulty than females. As such, the results cannot be generalized beyond predominately male athletes in the present study. Further studies are needed to examine associations between exhaling -inhaling circumstance data and more objective spirometry apparatus to precisely predict that a higher score indifference of exhale-inhale point would result in higher forced expiratory volume, confirming stronger and more functional respiratory status. Given the limiting data (selected sample and measuring instrument), it is suggested that the research could be conducted with a larger sample of subjects and that other measuring instruments could be added to assess the anthropological condition of the subjects. Generally, further research should focus on exploring different ways to increase a holistic approach in sport and sustain high levels of subjective vitality in athletes.

Several limitations are acknowledged in this study that merit consideration also in the methods section, the reliance on parametric statistical analysis for Likert scale data may have introduced potential biases. Additionally, the statistical analysis could have been strengthened by employing more robust methods, such as two-way between-within ANOVA and incorporating effect sizes.

CONCLUSION

A holistic and integrative exercise approach is crucial to increase the vitality of an individual's specific capacity during training. The increase in subjective vitality examined in this study could be one of the factors attributed to the enhancement of three-dimensional breathing and fluent spine mobility introduced by the BT protocol.

Our investigation into the differences in subjective vitality levels between two types of exercise suggests that BT may offer a potentially beneficial approach. It appears to be a short, gradual, and balanced holistic method that could enhance movement awareness in sports training, potentially reducing the risks of fatigue, injury, overtraining, and demotivation for athletes in their future training endeavours.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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IMPACT OF PHYSICAL ACTIVITY AND PHYSICAL FITNESS ON ACADEMIC PERFORMANCE: META ANALYSIS PROTOCOL

UGOTAVLJANJE VPLIVA TELESNE AKTIVNOSTI IN TELESNE ZMOGLJIVOSTI NA UČNO USPEŠNOST: PROTOKOL META ANALIZE

ABSTRACT

Physical activity and physical fitness are well-documented contributors to overall health, affecting various physiological and psychological outcomes. While some studies have reported a positive impact on academic performance, others have not found significant effects. Given these mixed results, the aim of this meta-analysis is to explore the effects of physical activity and physical fitness specifically on academic performance. Additionally, the research will examine whether the competencies of teachers delivering the physical activity interventions significantly influence the implementation of the intervention and how this impact manifests in the academic performance of children and adolescents. The Meta-Analysis will include searches in PubMed, Scopus, and ScienceDirect. The results will be crucial for understanding how measured physical fitness, in addition to increased physical activity, influences the academic performance of children and adolescents. By identifying the most effective types of interventions and the critical role of instructor competence, we can guide the development of more targeted and effective physical activity programs.

Keywords: Physical activity, physical fitness, academic performance, teaching qualifications, children

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IZVLEČEK

Telesna dejavnost in telesna zmogljivost pomembno prispevata k splošnemu zdravju, saj vplivata na različne fiziološke in psihološke kazalce. Medtem, ko nekatere študije poročajo o pozitivni povezanosti telesne dejavnosti in telesne zmogljivosti z učno uspešnostjo, pa nekatere niso ugotovile statistično značilnih učinkov. Glede na mešane rezultate prejšnjih študij, je cilj te meta-analize raziskati učinke telesne dejavnosti in telesne zmogljivosti, posebej vezano na učno uspešnost. Poleg tega bo raziskava preučevala, ali kompetence učiteljev, ki izvajajo telesno dejavne intervencije, pomembno vplivajo na izvedbo teh intervencij in kako se ta vpliv kaže na učno uspešnost otrok in mladostnikov. Meta-analiza bo vključevala iskanja v PubMed, Scopus in ScienceDirect. Poleg vpliva na povečano telesno dejavnost otrok in mladostnikov, bodo rezultati ključni tudi za razumevanje vpliva telesne zmogljivosti na njihovo učno uspešnost. Identificiranje najučinkovitejših vrst intervencij in vloge učiteljevih kompetenc, bo lahko v pomoč razvoju bolj ciljanih in učinkovitih programov telesne aktivnosti.

Ključne besede: Telesna dejavnost, telesna zmogljivost, učna uspešnost, pedagoške kompetence, otroci

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INTRODUCTION

Regular physical activity (PA), with appropriate intensity and duration, has a significant impact on the health of children, adolescents, and adults (Zhang et al., 2020). It contributes to improved cardiorespiratory endurance, metabolism, skeletal health, and psychosocial functioning (Franklin et al., 2022; Smith et al., 2014). Physical fitness (PF) is the ability to perform daily activities effectively without excessive fatigue (Clarke, 1979). It encompasses a range of physical attributes such as cardiorespiratory endurance, muscle strength and power, speed, agility, coordination, flexibility, and body composition. Better physical fitness is associated with a longer lifespan and a reduced risk of premature death, as it helps lower the risk of developing cardiovascular and other chronic diseases (Bouchard et al., 2012; Kvaavik et al., 2009; Laukkanen et al., 2016; Myers et al., 2015; Warburton & Bredin, 2017).

The fast pace of modern life and increasingly sedentary lifestyles contribute to a reduction in PA (Park et al., 2020; Sember, Jurak, Kovač, Đurić, et al., 2020) and consequently to issues such as overweight and obesity (Di Maglie et al., 2022). According to the recommendations of the World Health Organization (WHO), children and adolescents aged 5 to 17 should engage in an average of at least 60 minutes of moderate to vigorous physical activity daily. This activity should be mostly aerobic, spread throughout the week, and include both high-intensity activities and those that strengthen muscles and bones (World Health Organization, 2020).

While it is well-known that regular PA and good PF positively impact overall health (Laukkanen et al., 2016; Moon et al., 2020; Warburton & Bredin, 2017), we are interested in their impact on the academic performance (AP) of children and adolescents. Research indicates a positive correlation between cognitive abilities, PF and PA (Davis & Cooper, 2011; Fisher et al., 2011; Hillman et al., 2014; Kim et al., 2003; Sember, Jurak, Kovač, Đurić, et al., 2020). Sember et al. (2020) found with meta-analysis that there are positive (although relatively small) relationships between PA and AP. AP is not only influenced by the frequency and duration of PA but also by the intensity of the activity. Regular physical education classes and extracurricular activities are often the only regular PA (de Greeff et al., 2016; Garaulet et al., 2011; Sember, Jurak, Kovač, Morrison, et al., 2020) for many children. Therefore, the competencies of physical education teachers and other professionals conducting sports activities within school programs are crucial and can significantly influence the PA of pupils. The positive effect of PA is greater when conducted by more competent instructors, such as

physical education teachers or trained sports coaches (Jurak et al., 2013; Sember, Jurak, Kovač, Morrison, et al., 2020; Zorc & Pišot, 2003).

The aim of this meta-analysis is to investigate the impact of PA and PF on the AP of healthy children and adolescents aged 5 to 16 years. Additionally, it will explore whether the competencies of teachers delivering the PA interventions significantly influence the implementation of the intervention and how this impact manifests in the AP of children and adolescents. Given the mixed conclusions from systematic reviews with meta-analyses (Sember, Jurak, Kovač, Morrison, et al., 2020), which analysed 44 interventions where nearly half showed a positive impact on AP while the other half did not show a significant effect, it is crucial to understand how measured PF, in addition to increased PA, influences the AP of children and adolescents.

RESULTS

The meta-analysis will follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009) and will be registered with PROSPERO (ID: CDR132118).

Literature Search

Two reviewers (VS and JP) will independently search PubMed, Scopus, and ScienceDirect from June 2024 to September 2024. Unpublished studies will be excluded. Titles and abstracts will be screened using a predefined search string (children OR adolescents OR pupil) AND intervention AND school AND (physical fitness OR physical performance OR muscular fitness OR skill-related fitness OR motor abilities) AND (physical activity OR physical education OR extracurricular activity) AND (cognition OR academic performance OR academic achievement). References will be managed and deduplicated using Mendeley software.

Inclusion Criteria

Included studies will focus on the impact of physical activity or physical fitness, targeting individuals aged 7 to 15 years with no socio-economic disadvantages and an even gender distribution. Studies must report measurable outcomes related to physical activity or physical fitness, last longer than 12 weeks, include control and experimental groups, and involve more than 30 participants. Results with $p < 0.05$ will be recalculated using effect size (ES) metrics.

Data Extraction and Statistical Analysis

Data will be independently extracted by two reviewers (VS and JP). Discrepancies will be resolved through discussion. Data consistency will be checked against trial protocols and reports. The Hunter-Schmidt estimate and Fisher's z transformation will be used to address bias.

Studies will provide data to calculate standardized mean differences (ES) between groups, using Cohen's and Rosenthal's formulas. When multiple ES values will be available, the average ES will be used. The Hunter-Schmidt approach will convert ES to correlation (r_w), weighted by sample size to calculate the population effect (r_p). Variance due to sampling error (V_s) and the variance in ES (V_p) will be calculated, with 95% credibility intervals (CI_w) and heterogeneity assessed using I² and Q statistics. ES magnitudes will be described per Cohen and Sawilowsky. Risk of bias assessment will be performed and GRADE qualitative approach will be utilized (Iorio et al., 2015; Schünemann et al., 2013).

DISCUSSION

This protocol outlines the methodology for a comprehensive meta-analysis examining the impact of PA or PF on AP among individuals aged 6 to 15 years. By adhering to the PRISMA guidelines and registering with PROSPERO, we aim to ensure a rigorous and transparent approach to synthesizing existing research.

Relevance and Importance

PA and PF are well-documented contributors to overall health, affecting various physiological and psychological outcomes. This meta-analysis aims to explore these effects specifically on AP, a critical area that has garnered mixed results in previous studies (Álvarez-Bueno et al., 2017; Hapala, 2012; Mura et al., 2015; Singh et al., 2019). By focusing on peer-reviewed articles and dissertations, and ensuring the inclusion of control and experimental groups, this study will provide robust and generalizable findings.

Expected Contributions

We anticipate that this meta-analysis will clarify the extent to which physical activity and physical fitness influence AP. The recalculation of significant outcomes using effect size metrics will provide a nuanced understanding of these relationships. Furthermore, the examination of how the competencies of educators and intervention deliverers influence

outcomes will offer valuable insights into best practices for implementing physical activity programs.

Potential Challenges

Several challenges may arise during this meta-analysis. The heterogeneity of study designs, intervention types, and outcome measures could complicate data synthesis. However, the use of Hunter-Schmidt and Fisher's z transformation methods will help address potential biases and enhance the reliability of our findings. Additionally, the stringent inclusion criteria may limit the number of eligible studies, but this approach is necessary to ensure the validity of the results.

Future Directions

The findings from this meta-analysis will inform future research and policy recommendations. By identifying the most effective types of interventions and the critical role of instructor competence, we can guide the development of more targeted and effective physical activity programs. Moreover, understanding the relationship between physical activity, physical fitness, and academic performance will help educators and policymakers prioritize resources and strategies that maximize health and academic outcomes for children and adolescents.

CONCLUSION

In conclusion, this meta-analysis will provide a comprehensive assessment of the impact of physical activity and physical fitness on academic performance, contributing to the evidence base and informing future interventions and policies. Through rigorous methodology and thorough analysis, we aim to advance the understanding of how these critical factors influence the well-being and performance of young individuals.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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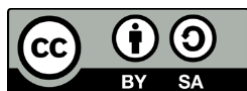
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INFLUENCE OF DIETARY HABITS ON BODY COMPOSITION IN LEBANESE ACTIVE UNIVERSITY STUDENTS: A GENDER SPECIFIC ANALYSIS

VPLIV PREHRANSKIH NAVAD NA TELESNO SESTAVO PRI AKTIVNIH LIBANONSKIH UNIVERZITETNIH ŠTUDENTIH: ANALIZA PO SPOLU

ABSTRACT

Problem Statement: The unhealthy lifestyle behaviors that university students face comprising sedentary behaviors are associated with weight gain and obesity in this critical life age. **Purpose:** The purpose of the study is to explore the effect of dietary habits on body composition parameters in Lebanese Active University Students according to gender. **Methods:** A sample of 200 students from the Lebanese University, faculty of education, physical Education department were studied. The standardized Dietary questionnaire (Turconi et al., 2003) was used to assess the dietary habits of the participants. **Body Composition** was assessed using the method of multifrequency bioelectrical analysis. Five body composition parameters were assessed: Body Height, Body Mass, Body mass index, Percentage Body Fat mass, and percentage of Skeletal Muscle mass. **Results:** Lebanese Physical Education students showed satisfactory results and scored above average in the four sections of the nutrition survey. Regarding gender-based classification, males showed better scores in sections of dietary habits and nutrition knowledge, while females showed better scores in physical activity rated level, and nutrition beliefs. Regarding **Body Composition**, Lebanese students were found in normal body weight. The multiple regression analysis technique showed that the dietary habits factor has mild to moderate influence on body composition specifically on its three tested dependent variables: BM, BFM, and SMM. **Conclusion:** Findings support the need from educational and health authorities to develop and evaluate health-promotion and obesity-prevention programs for university communities especially for female gender with regular healthy lifestyle monitoring and standardized assessments.

Keywords: University students, Lifestyle, Dietary Habits, Health, Body Composition

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IZVLEČEK

Problem: Nezdrav življenjski slog, zaznamovan s sedečim vedenjem, s katerim se soočajo univerzitetni študentje, je povezan s pridobivanjem telesne mase in debelostjo v tem kritičnem življenjskem obdobju. **Namen:** Namen študije je raziskati vpliv prehranskih navad na parametre telesne sestave pri aktivnih libanonskih univerzitetnih študentih po spolu. **Metode:** Vzorec je vključeval 200 študentov z Libanonske Univerze, Fakultete za izobraževanje, oddelka za športno vzgojo. Za oceno prehranskih navad udeležencev je bil uporabljen standardiziran prehranski vprašalnik (Turconi et al., 2003). **Telesna sestava** je bila ocenjena z metodo multifrekvenčne bioelektrične analize. Ocenjenih je bilo pet parametrov telesne sestave: telesna višina, telesna masa, indeks telesne mase, odstotek telesnega maščevja in odstotek skeletne mišične mase. **Rezultati:** Libanonski študenti športne vzgoje so pokazali zadovoljive rezultate in dosegli nadpovprečne rezultate v vseh štirih delih prehranske ankete. Glede na razvrstitev po spolu so moški dosegli boljše rezultate v delih o prehranskih navadah in prehranskem znanju, medtem ko so ženske dosegle boljše rezultate v ravni telesne aktivnosti in prehranskih prepričanjih. Glede telesne sestave so bili libanonski študenti v območju normalne telesne mase. **Multipla regresijska analiza** je pokazala, da imajo prehranske navade blag do zmeren vpliv na telesno sestavo, zlasti na tri testirane odvisne spremenljivke: TM, TMF in SMM. **Sklep:** Ugotovitve podpirajo potrebo izobraževalnih in zdravstvenih oblasti po razvoju in oceni programov za promocijo zdravja in preprečevanje debelosti za univerzitetne skupnosti, zlasti za ženski spol, z rednim spremljanjem zdravega življenjskega sloga in standardiziranimi ocenami.

Ključne besede: univerzitetni študenti, življenjski slog, prehranske navade, telesna sestava

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INTRODUCTION

Diet and physical activity significantly impact health, fitness, weight management, and chronic diseases prevention (Kljajevic et al., 2021). Obesity is caused by consuming more energy than needed, resulting in fat accumulation. Eating only enough to balance energy output daily can leave accumulated fat unchanged, leading to physical and psychological harm and reduced life expectancy (James, 2004).

Young adults in universities face challenges like adjusting to a new environment, study stress, time management issues, and a crowded schedule, leading to a lack of health awareness. They engage in unhealthy habits like meal skipping, snacking, fast food consumption, smoking, and excessive internet use (Ganasegeran et al., 2012). Sedentary activities (such as watching television, sitting, and computing) have also been associated with obesity and weight gain (Ganasegeran et al., 2012; Meyer et al., 2008).

Body composition analysis is a crucial screening method for controlling nutritional and health status, indicating changes in health and being a sensitive factor in biological understanding. (Wang et al., 1992; Ellis, 2000). Wang et al. (2004) stated, "Nutritional status, physical activity level, and disease state alter body cell mass, which in turn serves as a biomarker of these processes" (Wang et al., 1992; Wang et al., 2004; Ellis, 2000).

Poor dietary habits have become more prevalent among Arab children and adults over the years (Rahim et al., 2014). During the past few years, Lebanon has seen a nutritional shift in its eating habits, moving from the conventional Mediterranean diet to a fast food pattern. Young individuals in Lebanon have dietary patterns that are influenced by the fast-food sector. Young people are consequently growing more and more overweight and obese (FAO, 2010).

According to the findings of research conducted in various countries around the world, insufficient activity, a poor quality diet, and smoking are critical health concerns among college students (Irwin, 2004; Steptoe et al., 2002). Literature have confirmed that overweight has been highly detected in university settings (Deliens et al., 2015; Vella-Zarb et al., 2009; Yahia et al., 2016; Martins et al., 2021). To the best of our knowledge, only two Lebanese studies conducted on non-sport university students founded that the majority of those students have normal weight but low dietary habits (Assaf et al., 2019; Yahia et al., 2008).

Due to all the above, it can be concluded that there is a need for a study in which to identify the Dietary Habits and Body Composition profiles among the Lebanese active university students

and explore the effect of dietary habits on body composition parameters according to gender characteristics.

It could be hypothesized that Dietary Habits is an independent factor that statistically significantly affect the quality of body composition in Lebanese university students. Promoting general health and well-being in this demographic requires an understanding of the food preferences and body composition profiles of active university students in Lebanon. The study intends to understand the food preferences and body composition profiles of active university students in Lebanon, providing insights for interventions and educational programs to improve nutritional practices and physical fitness.

METHODS

Design of the Study

This research is an Applied Deductive Quantitative Research - Cross-sectional Descriptive study.

Sample Characteristics

The study sample consisted of Two hundred (200) sportive students, males (n= 100) and females (n=100) with a mean age of 22.1 ± 4.1 years. Participants have fully completed the online survey and did the anthropometric measurements. They were recruited from the faculty of education, physical education and sport major at the Lebanese university.

The inclusion requirements for the participants, who were of college age, included being enrolled full-time in the three years of the bachelor's degree programme. Any chronic illness, major injury, or disability that prevents one from participating in body composition assessments was an exclusion criterion. Students were chosen at random from the physical education and sport classes by the student affairs office.

Data Collection and Testing Procedures

Two steps were applied to collect relevant data. First of all, students had to fill out the Eating Habits questionnaires, then they had to complete the anthropometric and body composition measurements.

Step 1 – The study used a self-reported questionnaire (Turconi, 2003) to assess eating habits, focusing on food consumption frequency, Eating habits, physical activity, dietary beliefs, and nutrition knowledge. The questionnaire was administered through Google Forms, ensuring confidentiality and anonymity. The results showed acceptable reliability with Cronbach's alpha ranging from 0.55 to 0.75 and statistically significant Pearson correlation coefficients.

Step 2 – After questionnaires being filled out, body composition measurements, including body height, weight, body fat percentage, skeletal muscle mass, and body mass index have been measured using InBody 270 analyzer (Biospace Co. Ltd, Seoul, Korea. Participants stood on a scale with bare feet and hands, avoiding food or drink for at least 3 hours before the measurements to ensure accuracy.

Body mass had been measured to the nearest 0.1 kg with the subjects dressed in light clothing. Barefoot, standing height had been measured to the nearest 0.5 cm with a wall-mounted stadiometer.

Participants in this study gave their consent to participate. In order to confirm their involvement in the study, participants were requested to sign a consent form, which was completed by having them respond to an initial question on the questionnaire. Additionally, students were given the assurance that the data collected would be kept private and utilized only for scientific research.

The data have been collected during the 2021. The research protocol was recognized in the Declaration of Helsinki (World Medical Association, 2013) and it was approved by the Ethical Committee of The Faculty of Sports and Physical Education in the University of Belgrade under the number of 484–2 (Appendix 1).

Statistical Procedures

All of the statistical analyses were carried out using IBM's Statistical Package for the Social Sciences (SPSS, version 25). A significance level of $p < 0.05$ has been established. The measures of central tendency and variability in descriptive statistics are presented by the mean, standard deviation (SD), minimum, maximum (max), and coefficient of variation (cV%). Furthermore, for each of the two student samples, the significant differences in the food habits variables were ascertained using the Mann Whitney U test. Finally, to investigate the significant effects of dietary habits on body composition measures, the Multiple Regression Analysis (MRA) technique utilizing backward elimination was carried out.

RESULTS

Descriptive Statistics

Anthropometric Measurements and Physical Activity

Male students were, as predicted, typically taller and heavier than female pupils. It is evident that male students have greater values for the majority of BC characteristics, which adds to their higher total body mass. The exception is that women have a higher body fat percentage than men do (12.0% vs. 22.2%). Although females had a greater mean body fat percentage than males, both genders' values fell within the range of acceptable body fat percentages (10–20% for men and 18–28% for women) (InBody, 2018). The National Heart, Lung, and Blood Institute (1998) and Nuttal (2015) have defined the normal weight range as being occupied by the mean estimated BMI ranges for all study groups.

According to BMI values, the majority of examined students (82% male and 78% female) had normal weight (BMI in range of 18.50 and 24.99 kg/m²). Among the two sample groups, the BMI percentages were categorized as follows:

Sample one or Sport males (n=100) scored the following BMI percentages: (underweight level = 0%, Normal Weight level = 82%, overweight level = 18%, and obese = 0%).

Sample two or sport females (n=100) scored the following BMI percentages: (underweight level = 17%, Normal Weight level = 78%, overweight level = 5%, and obese = 0%)

The aforementioned results and all other results are shown in Tables 1 and 2.

Table 1: Body Composition Descriptive Statistics for Male PE and Sport students

Variable	Mean	SD	Min	Max	cV (%)
BH (cm)	177.0	0.07	159.0	199.0	3.8
BM (kg)	72.8	10.2	52.9	102.2	13.7
BMI	23.2	2.4	18.6	29.3	10.4
PBFM (%)	12.0	4.3	5.0	23.6	35.6
PSMM (%)	47.7	6.7	26.9	68.8	12.7

Notes. Table processed by the authors.

Table 2: Body Composition Descriptive Statistics for Female PE and Sport students

Variable	Mean	SD	Min	Max	cV (%)
BH (cm)	164	0.06	152	177	3.4
BM (kg)	56.4	7.0	42.3	73	12.5
BMI	20.9	2.3	15.9	27.7	10.9
PBFM (%)	22.2	5.8	11	35.4	27.6
PSMM (%)	33.3	3.4	25.5	42.0	8.1

Notes. Table processed by the authors

Regarding the Nutritional Habits assessment presented in table (3) placed in the tables' section, the Mann-Whitney U Test that measured the mean scores of the Nutrition Survey sections for both genders have found in general that in the first section (Dietary Habits), both genders scored satisfactory results with no significant difference in the mean of the section score (.228). Almost one third of the students reported frequent consumption of at least two portions of fruits per day (27% males, and 34% females) while females were healthier at consuming vegetables by 62% to 38% of males. Sweets/cakes at meals were occasionally consumed by students of both male and female genders (56% vs 57%, respectively) ($p=.527$). Regular three meals per day consumption was reported by 51% of the males and 59% of females.

Table 3: Mean Scores of the Nutrition Survey sections by Gender- Mann-Whitney U Test

Questionnaire Section	Scores	Males (100)	Females (100)	p value
Dietary Habits Total Score 52	Lowest	22.8	21.3	.228
	Mean	35.8	35.1	
	Highest	47	44.6	
Physical Activity and Lifestyle- Total Score 24	Lowest	9.0	11.5	.519
	Mean	16	16.2	
	Highest	19	18.1	
Dietary beliefs Total Score 12	Lowest	7.0	8.3	.031
	Mean	8.9	9.3	
	Highest	10	11.1	
Nutrition Knowledge Total Score 11	Lowest	5.4	2.0	.016
	Mean	6.7	6.3	
	Highest	9.0	10.1	

Notes. Table processed by the authors.

As for the Physical Activity section result, the gender based classification showed that both genders were equally active since male students ($n=100$) have scored a mean of 16 while females ($n=100$) had a mean score of 16.2 ($p=.519$). Around one third of male students (28% and 34%) rated their lifestyle from moderately active to very active respectively, while (49% and 24%) of female students rated their lifestyle from moderately active to very active respectively.

Regarding the Dietary Beliefs section, students showed sufficient comprehension of the meaning of a healthy diet, especially females with a clear significant difference (.039). The total score for this section was 12 and the mean score for females was 8.9 for males and 9.3 for females. Students responded correctly to the three questions related to the meaning of a healthy diet in both sample groups.

Finally, the total score for the nutritional knowledge section was 11 and the mean score for females was 6.3 and for males was 6.7 where there was a statistically significant difference in questions' responses between genders ($p=.016$). Males reported better nutritional knowledge on questions related to foods rich in dietary fibers, foods low in fat, foods rich in protein, different food substances containing energy, functions of vitamins and minerals, and on questions related to the "definition" of daily energy expenditure.

Multiple Regression Analysis: Predictions of Body Composition using Nutrition Measures

Based on the purpose of this study in examining the effect of dietary habits on body composition among Lebanese universities' students according to gender, the multiple regression analysis technique (MRA) using backward elimination was conducted to examine the significant impacts of dietary habits on body composition parameters.

Regarding examining the impact of nutrition on body composition, the independent variables of two sections of the dietary survey (Turconi et al., 2003) were used as predictors; frequency of food consumption including 10 variables, and Dietary habits including 13 variables. However, the dependent variables were the three major body composition parameters: Body mass (BM), Body Fat Mass (BFM), and Skeletal Muscle Mass (SMM).

Predictions that are presented below with relevant tables among the two student samples were chosen for only predictions carrying significant impact of independent variables on the dependent variable where the analysis of variance (ANOVA) determines a $p < 0.05$, R is above .5 indicating a moderate correlation between the variables, R^2 is above .25 indicating that the

predictor explains more than quarter of variability in the predicted variable, t values of all predictors are above 1.96, which indicates a significant impact on the dependent variable.

Sample 1 (Male Sport Sample)

In Sample one (Male sport students), neither the dietary habits nor the frequency of food consumption predicted body composition since all models including combination of variables of these two sectors extracted by multiple regression analyses using backward elimination showed that no significant impact of both independent variables on all three body composition variables BM, BFM, and SMM. The only significant impact on body composition in sample one was determined by Dietary habits variables on BFM.

A – Dietary Habits Predictors and BFM

In this category, the backward multiple regression analysis extracted 13 models to examine the impact of dietary habits on BFM. The best-fit model was model 6 including one to one and half liter of mineral water daily, beverages between meals, beverages at breakfast, two portions of fruit daily, diet content, one glass of milk or cup of yogurt daily, two portions of vegies daily, eating breakfast, $F(13, 86) = 2.077$, $p < 0.05$, the $R^2 = .154$ which indicates that the model explains 15.4% of the variability in BFM. The analysis of variance (ANOVA) showed a p value of .046 in this model which is considered significant.

Sample 2 (Female Sport Sample)

In Sample two, the nutrition sections frequency of food consumption and dietary habits carried a significant impact on body composition. The multiple regression analyses using backward elimination in this sample showed significant impacts of few models in the independent variables on all three-body composition variables BM, BFM, and SMM.

A – Frequency of Food Consumption Predictors and BM

Seven models were extracted by backward multiple regression analysis in this category to examine the impact of frequency of food consumption on body mass. All seven models carried significant impact on BM according to the analysis of variance (ANOVA) $p = .000$. The best-fit model was model 4 including Pizzeria/week, sweets/week, fish/week, fatty meat/week, fried potato/week, legumes/week, cheese/week, $F(10, 89) = 5698$, $p < 0.05$. The $R^2 = .296$ which indicates that the model explains 29.6% of the change or variance in BM.

B – Frequency of Food Consumption Predictors and BFM

In this category, backward multiple regression analysis extracted four models to examine the impact of frequency of food consumption on BFM. The best-fit model was model 3 including Pizzeria/week, eggs/week, sweets/week, fish/week, fatty meat/week, fried potato/week, fast food/week, $F(10, 89) = 5.791$, $p < 0.05$, $R^2 = .337$ which indicates that the model explains 33.9% of the variance in BFM. The analysis of variance (ANOVA) showed a $p = .000$ in this model indicating a significant impact on the dependent variable BFM.

C – Dietary Habits Predictors and BM

In this category, the backward multiple regression analysis extracted eight models to examine the impact of dietary habits on BM. The best-fit model was model 2 including one to one half liter of mineral water daily, cake/dessert at meals, beverages between meals, breakfast content, beverages at breakfast, two portions of fruit daily, diet content, three meals daily, diet type, one glass of milk or cup of yogurt daily, two portions of vegies daily, eating breakfast, $F(13, 86) = 6.013$, $p < 0.05$, the adjusted $R^2 = .453$ which indicates that the model explains 45.3% of the variability in BM. The analysis of variance (ANOVA) showed a p value of $.000$ in all models.

D – Dietary Habits Predictors and BFM

In this category, the backward multiple regression analysis extracted eight models to examine the impact of dietary habits on BFM. The best-fit model was model 7 including one to one half liter of mineral water daily, cake/dessert at meals, beverages between meals, breakfast content, beverages at breakfast, one glass of milk or cup of yogurt $F(13, 86) = 9.742$, $p < 0.05$, the $R^2 = .426$ which indicates that the model explains 42.6% of the variability in BFM. The analysis of variance (ANOVA) showed a p value of $.000$ in all 8 models.

E – Dietary Habits Predictors and SMM

In this category, the backward multiple regression analysis extracted eight models to examine the impact of dietary habits on SMM. The best-fit model was model 3 including One to one half liter of mineral water daily, cake/dessert at meals, beverages between meals, breakfast content, beverages at breakfast, two portions of fruit daily, three meals daily, diet type, one glass of milk or cup of yogurt daily, two portions of vegies daily, eating breakfast, $F(13, 86) = 3.876$, $p < 0.05$, the $R^2 = .326$ which indicates that the model explains 32.6% of the variability in SMM. The analysis of variance (ANOVA) showed a p value of $.000$ in all 9 models indicating a significant impact of this model on SMM.

DISCUSSION

The purpose of the study is to explore the effect of dietary habits on body composition parameters in Lebanese Active University Students according to gender.

The study found that women's body fat mass percentage was higher than men's, but still within InBody's (2018) healthy range. This may be due to women being more self-conscious about their weight and body shape, and the desire for "thinness" in university settings (Sheldon et al., 2010; Ferguson et al., 2011). Moreover, and from a scientific perspective, this result could be attributed to the fact that men have more muscular mass and lean body mass due to their higher testosterone production. They have higher visceral fat and less subcutaneous fat. Women, however, have greater subcutaneous fat and less muscle mass due to hormonal factors (Gropper et al. 2011).

According to the National Heart, Lung, and Blood Institute (1998), the BMI ranges for both samples were 18.50–24.99 kg/m², which is deemed normal. The BMI readings of men were greater than those of women. Students who are overweight or obese when they are younger have a higher likelihood of remaining obese as they age (National Research Council and Institute of Medicine, 2013; Strong et al., 2008).

In terms of PBFM, male students from Lebanon achieved higher averages (12%) than those from Poland (Gdansk) and Spain (Murcia), with male students from Madrid (Spain) coming in at 16.5%, Valencia (Spain) at 18.75%, and Valparaíso (Chile) at 22.73% (Lopez Sanchez, 2019). Furthermore, according to Dropsaj et al. (2015), the average BMI of Lebanese female students (20.9 kg/m²) was comparable to that of Serbian university of Belgrade female students (21.7 kg/m²). In addition, both of the Lebanese male student sample groups had appropriate percentages of skeletal muscle mass (PSMM), ranging from around 50%, which was greater than the percentage of male Abu Dhabi police officers (42.2%).

As for Dietary Habits, results showed that students of both genders have satisfactory results. The dietary habits survey (Turconi et al., 2003) addressed to both students' samples and included four sections (Dietary Habits, Physical Activity and Lifestyle, Dietary Beliefs, and Nutritional Knowledge) showed mean scores above averages in all sections.

The study by Yahia et al. (2016) found that American university students have healthier nutrition habits, better physical activity, dietary beliefs, and nutritional knowledge compared to Lebanese students. In Dietary Habits section, the Lebanese and American male students scored

similar average percentages (68.8%, and 67.3%). However, American female students scored higher average percentage (71.1%) than their Lebanese peers (67.5%). In the Physical Activity section, the American male students' average percentage (76%), and the female students' average percentage (70%), were higher than the Lebanese students' males and females scores (66.7%, and 67.5% respectively). In the Dietary Beliefs section, similar average percentages were scored by American and Lebanese male students (74.7%, and 74.2% respectively). However, American female students scored higher average percentage (82%) than the Lebanese females (77.5%). The final section in the nutrition survey was the nutrition knowledge. Lebanese students scored lower averages percentages also with (60.9%) for males, and (57.3%) for females, while the American students scored (68.8%) and (63.8%) for males and females respectively.

The study found that (27% of males, and 34% of females) of Lebanese students consume at least two portions of fruits daily, while 62% of females and 38% of males of males consume vegetables. This is lower than the result of (Yehia et al., 2016) study where almost half of American students consume at least two portions daily, especially females. Low fruit and vegetable consumption is associated with obesity (Lin & Morrison 2002; Cho et al., 2003; Tohill et al., 2004).

Results of (Yahia et al. 2016) study regarding daily breakfast intake percentages (53%) were lower than the Lebanese sample students (63%). However, the Lebanese and American university students' percentages scores regarding daily breakfast intake were lower than their Canadian university colleagues (89.3%) in the study of Lachance et al., (2010). Eating breakfast helps to lower dietary fat intake and minimize impulsive snacking (Schlundt et al., 1992; Yahia et al., 2008).

Regular three meals per day consumption was reported by around half of the Lebanese students (51% males, and 59% females. This result regarding this variable were higher than the American students' results (43% of males and 38% of females).

In Daily water consumption of at least 1–1.5 L, males had healthier dietary habits from females with clear significant differences. For instance, females showed (66%) and males showed (81%) with a gender significant difference ($p = .019$). In comparison to (Yahia et al., 2016) results regarding these dietary habits variable, same gender significant difference in the daily water consumption was established as more males, than females, reported daily water consumption of at least 1–1.5 L ($p = .001$).

In the Physical Activity and Lifestyle section, outcomes of this section indicated that the Lebanese students reported a high physically active lifestyle. In addition, the gender-based classification in this section showed that both genders were equally active.

Regarding the gender-based classification; most male students (79%) and almost all female students (99%) reported practicing physical activity during the entire year, 78% of males and (62%) of females reported practicing more than 4h per week. Around one third of male students (28% and 34%) rated their lifestyle from moderately active to very active respectively, while (49% and 24%) of female students rated their lifestyle from moderately active to very active respectively. As compared to the American students of Central Michigan University, half of American students reported being physically active but only about one-third of the students (33%) reported exercising more than 4h per week. Males were more active than females.

In the Dietary Beliefs section, results indicated that students have sufficient comprehension of the meaning of a healthy diet, especially females. These results are in line with other studies (Turconi et al., 2008; Croll et al., 2001) and suggest that students' comprehension of the meaning of healthy and unhealthy diet does conform to dietary guidelines (Dietary Guidelines Advisory Committee, 2010).

In the final section of (Turconi et al., 2003) questionnaire, the Lebanese students were determined with satisfactory nutritional knowledge, but male students reported better knowledge in areas like dietary fibers, energy, vitamins, minerals, and energy expenditure. This gender based results on nutrition knowledge section contrasts the results of (Yahia et al., 2016; Von Bothmer & Fridlund, 2005) who found that female students had a higher nutritional knowledge score than male students. Females, in general, are more likely than males to be interested in nutrition, weight control, and to make positive changes (Von Bothmer & Fridlund, 2005; Livingston et al., 2012).

The study examined the impact of dietary habits on body composition in two students' sample groups using the multiple regression analysis. Results showed that dietary habits have a mild to moderate impact on body composition, specifically on three dependent variables: body mass index (BM), body fat mass (BFM), and body mass index (SMM). In males, dietary habits had a mild impact on BFM, while in females, they had a moderate impact on BFM. The best-fit model, which included daily mineral water intake, breakfast content, and dairy consumption, explained 42.6% of the variability in BFM.

Our study results determined by the multiple regression analysis used for the purpose of examining the significant impacts of physical activity and dietary habits on body composition shared partial similarity with (Kukic & Dopsaj, 2017) study that defined the factors that influence the structure of the body composition in Abu Dhabi police workforce using the factorial analysis of variance. The authors founded that three independent factors influence body composition: Factor 1 – Physical Inactivity and Nutrition, Factor 2 – Physical Inactivity and Exercise, and Factor 3 – Sedentary Lifestyle. Our findings were consistent with the first factor of this study analysis, which considers that nutrition has a significant impact on body composition. In other words, it has been known that body composition is the result of various factors such as diet, stress, the amount of physical activity and other factors that are parts of daily habits (Kukic & Dopsaj, 2017).

CONCLUSION

The study found that the Lebanese University male students dominate body composition measurements, dietary habits and nutrition knowledge sections, while female students show superior results in dietary beliefs and physical activity and lifestyle sections.

Nutrition Habits had a mild to moderate impact on body composition, specifically on BM, BFM, and SMM. The research hypothesis considering that Dietary Pattern is an independent factor affecting body composition quality in Lebanese university students is accepted.

Future studies should involve larger samples from different regions, socio-economic backgrounds, academic specialties, and higher ages, and use objective measurement methods like personal interviews, physiological markers, calorimetry, and motion sensors.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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CAN SIMPLE REACTION TIME TO A VISUAL STIMULUS BE USED AS A MEASURE OF THE BALANCE TASK INTENSITY?

ALI JE LAHKO ENOSTAVEN REAKCIJSKI ČAS NA VIDNI SIGNAL MERA RELATIVNE INTENZIVNOSTI RAVNOTEŽNE NALOGE?

ABSTRACT

Correctly determining the frequency, intensity and duration of balance tasks (BT) is crucial for effective balance training. While the frequency and BT duration are well defined, understanding BT intensity remains limited. Higher BT intensity demands greater attentional capacity for postural control. To assess the role of attention in postural control the dual-task paradigm including BT with reaction time (RT) is often used, suggesting RT as a potential measure of BT relative intensity. The study aimed to determine whether simple RT can be a surrogate for the relative BT intensity. Twenty randomly selected participants performed six repetitions of two-legged and one-legged stances on firm and compliant surfaces on a force plate. During the execution of the BT, the participants had to react on illumination of the light by pressing a switch held in their dominant hand. The center of pressure (COP) velocity and the RT were investigated. The BT were categorized into low, moderate and high intensities. The results showed a significant increase in COP velocity from low to high intensity BT ($p=0.001$; $\eta^2=0.79$). Moderate intensity BT resulted in a 123.6% increase in COP velocity compared to the low intensity BT. During high-intensity BT COP velocity increased by 244.2 % ($p < 0.001$). There were no differences in RT between different BT intensities ($p=0.596$; $\eta^2=0.03$). The results suggest that RT may not accurately reflect the BT intensity. Therefore, it can be concluded that simple visual RT could not be used as a measure of relative intensity of BT.

Keywords: relative intensity, simple reaction time, dual tasks, FITT

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IZVLEČEK

Za optimalen učinek treninga ravnotežja je pomembno ustrezno odmeriti frekvenco, trajanje in intenzivnost BT. Medtem ko sta frekvenca in trajanje BT dobro opredeljeni, relativna intenzivnost BT še vedno ostaja neopredeljena. Višja kot je intenzivnost BT, višja je zasedenost kapacitete pozornosti, ki je potrebna za nadzor in upravljanje drže ter ravnotežja. Za oceno zasedenosti kapacitete pozornosti se najpogosteje uporabljajo dvojne naloge, ki vključujejo BT in reakcijski čas (RT). Slednji predstavlja potencialno mero relativne intenzivnosti BT. Cilj študije je bil določiti ali je lahko enostaven RČ na vidni dražljaj mera relativne intenzivnosti ravnotežne naloge (BT). V študiji je sodelovalo dvajset preiskovancev, ki so izvedli šest ponovitev sonožne in enonožne stoje na trdni in mehki površini na pritiskovni plošči. Preiskovanci so morali med BT na prižig lučke čim hitreje odreagirati s pritiskom stikala v dominantni roki. Preučevani parametri so bili hitrost oprijemališča sile reakcije podlage (COP) med BT in RT. BT so bile razdeljene na nizko, zmerno in visoko intenzivne. Rezultati analize so pokazali značilen dvig hitrosti COP od nižje proti visoko intenzivni BT ($p=0.001$; $\eta^2=0.79$). Zmerna intenzivna BT je imela za 123.4 % višjo hitrost COP v primerjavi z nizko intenzivno BT. Med visoko intenzivno BT se je hitrost COP povišala za 244.2 % ($p < 0.001$). V RT med različnimi intenzivnostmi BT ni bilo razlik ($p=0.596$; $\eta^2=0.03$). Na podlagi rezultatov lahko sklepamo, da RT ne odraža intenzivnosti BT. To pomeni, da enostavni RT ne more biti objektivna mera relativne intenzivnosti ravnotežnih nalog.

Ključne besede: relativna intenzivnost, enostavni reakcijski čas, dvojne naloge, FITT

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INTRODUCTION

Balance training includes various balance tasks (BT). An evidence-based dose-response relationship of balance training is critical for maximising improvements in postural control. The dose-response relationship of balance training is determined by the frequency, intensity and duration of BT (Thompson et al., 2010). While the frequency and duration of BT have been defined in numerous studies, the intensity of BT remains uncertain. In fact, Farlie et al. (2016) found no statistically significant correlation between individual progress in balance tests and the frequency and duration of BT. Furthermore, these factors explain only 2.15 % of the variance in individual balance progress, emphasising that improvements in postural control also depend on the intensity of BT. Current BT recommendations only specify absolute intensity (Thompson et al., 2010; Tiedemann et al., 2011), while the definition of relative intensity is still unclear. Since each person has unique balance abilities, quantifying the relative intensity of BT remains crucial. Attempts have been made to determine the relative intensity of BT using the Perceived Exertion Scale (RPE) or the Perceived Stability Scale (RPS), in which people self-assess the intensity of BT (Espy et al., 2017), but their validity has not been proven yet.

The BT differ in terms of sensory conditions and stability. It was found that centre-of-pressure (COP) movement parameters increased significantly, when the use of sensory information or the support surface was gradually reduced (Muehlbauer et al., 2012). For example, a greater COP velocity in the monopodal stance compared to the two-legged stance has been observed (Muehlbauer et al., 2012). While a greater COP velocity could serve as an absolute measure of BT intensity, it is insufficient for determining the relative intensity of BT as it does not provide an indication of how much of the maximal capacity of a person's postural control system (i.e., a general name for the complex interplay of the musculoskeletal and nervous systems to control our bodies in space) was used. Although, a direct measurement of the maximum capacity of the postural control system is not yet possible, it has been shown that the attentional capacity required for postural control increases when the use of sensory information or the support surface is gradually reduced (Lajoie et al., 1993). For instance, a greater COP velocity in the monopodal stance compared to the two-legged stance was found to lead to a greater attentional capacity used for postural control (Wulf & Shea, 2007). Furthermore, it has been shown that older participants switch from an automatic to an attentional postural control strategy (Ruffieux et al. 2018) as they receive less sensory information. To assess the role of attention in postural control in healthy populations, the dual-task paradigm has often been used. The dual-task paradigm typically involves the assessment of BT with simple or choice reaction times observed

following visual or auditory stimuli. (Just & Carpenter, 1992). In particular, Lajoie and colleagues (1993) found that RT increased from sitting to standing and from narrow standing to walking. An increase in RT implies that attentional capacity to respond rapidly decreases as a function of postural complexity (Just and Carpenter, 1992; Lajoie et al., 1993). Accordingly, the relative intensity of BT can be viewed as the remaining attentional capacity to respond to visual stimuli (Jehu et al., 2015).

To summarise, according to capacity sharing theory (Wickens, 1989), as the complexity, i.e., intensity, of the BT increases, both the BT and the RT task compete for the limited information processing capacity, which could lead to an increase in RT. Therefore, RT can be used as a measure of the relative intensity of the BT, but that have not been proven yet. To our knowledge, there are only few studies that systematically increase the intensity of BT and simultaneously measure the RT. However, these studies have not yet succeeded in determining the measure of relative intensity of BT (Lajoie et al., 1993; Remaud et al., 2013; Jehu et al., 2016). In their study, Jehu et al. (2016) measured simple and choice auditory RT during two-legged and semi-tandem stance in older adults. After five sessions of performing simple and choice auditory RT during the BTs, they concluded that there were no significant differences in simple RT, and furthermore the variability in choice RT remained high. Additionally, Lajoie et al. (1996) and Remaud et al. (2013) as well measured RT to auditory, rather than visual stimulus during BTs. Therefore, the aim of this study was to investigate the changes in simple RT to visual stimulus during BT of different intensities. We hypothesised that reducing the base of support and decreasing the use of sensory information would increase COP velocities. Additionally, we hypothesised that participants would increase their RT to visual stimuli during the more difficult posture and that the RT dual-task paradigm could be used as a surrogate for the relative intensity of the BT.

MATERIALS AND METHODS

Participants

In the study, 20 randomly selected healthy and uninjured students from the Faculty of Sport voluntarily participated, 12 were male and 8 were female. The average age of the participants was 23.8 ± 7.1 years, the average body weight was 71.9 ± 10.6 kg and the average height was 175.3 ± 8.8 cm. The participants did not undergo a regular training process. All participants were informed about the measurement procedures, the possible risks and the consequences of

participation, and their participation was confirmed by written consent prior to the measurements.

Experimental protocol

The measurements were carried out in the Laboratory of Kinesiology at the Faculty of Sport at the University of Ljubljana. The participants took part in the measurements individually, once and in random order. The experimental protocol consisted of 3 randomly assigned BT. Two-legged stance on firm surface was determined as low intensity BT. One-legged stance on firm ground was determined as moderate intensity BT (reduced support surface). One-legged stance on compliant surface was determined as high intensity BT (reduced support surface and reduced sensory information). Before the measurements, each participant was thoroughly familiarised with the execution of the individual BTs. The participants were instructed to press the switch held in the dominant hand as quickly as possible as soon as the LED light lit up during the BT. The participants were not instructed to prioritise the RT or the execution of the BT. The Student Affairs Commission at the Faculty of Sport, University of Ljubljana, approved the study (No. 2019/20/13) to ensure that all ethical standards were met and that the study was conducted in accordance with the Declaration of Helsinki (World Medical Association, 2013).

Balance task and RT measurement

Each BT was performed for 10 seconds, followed by a 50-second rest period. Participants repeated each BT six times, with a 3-minute rest in between. During the execution of each BT, RT was measured in response to a visual stimulus triggered by a red LED light of 200 ms duration located 1.89 m from the force plate. The light illuminated at random intervals during the BT, and participants were required to respond by rapidly pressing the switch they held in their dominant hand. The switch was connected to a DAQ interface (PowerLab 16/35, ADInstruments, Bella Vista, Australia). The time elapsed from stimulus onset (illumination of the LED light) to switch press was defined as a simple RT. To avoid anticipation, the measurement was repeated if the participants' RT was less than 100 ms, as such a short time indicates anticipation of the event. LabChart v7 software (ADInstruments, Bella Vista, Australia) was used to read out all recorded signals. The recorded signals were used to measure the RT during the execution of BT. The average RT for six repetitions of each BT was then calculated and these values were used for statistical analysis.

In the two-legged stance, the participants placed their feet hip-width apart, and in the one-legged stance the participants stood on the dominant leg. Participants performed all BT barefoot and

with their arms crossed on their chest on a force plate (Kistler 9286 AA, Winterthur, Switzerland). An AIREX balance cushion (50×41×6 cm) was used when participants performed the one-legged stance on a compliant surface. During all balance tasks, the analogue signal obtained from the force plate was amplified (Kistler, Winterthur, Switzerland, model 9865A), recorded and read out via a digital-analogue interface (PowerLab16/35 - ML880/P, ADInstruments, Bella Vista, Australia). The data was sampled at a frequency of 1000 Hz. The COP velocity (mm/s) one second before the light signal was calculated from the acquired signals. The average COP velocity for six repetitions of each BT was then calculated and these values were used for statistical analysis.

Statistical analysis

The statistical analysis was performed using IBM SPSS 26 (SPSS Inc., Chicago, Illinois, USA) and Microsoft Excel (version 2016, Microsoft Corporation, Redmond, Washington, USA). Mean values and standard deviations were calculated for the analysed parameters. The uniformity of the distributions was assessed using the Kolmogorov-Smirnov test for numerical variables. The intraclass correlation coefficient (ICC) and with a 95 % confidence interval was used to test the repeatability of the RT and COP velocity measurements and interpreted according to the statistical guidelines defined by Koo and Li (2016). The repeatability of the measurements was considered acceptable when the ICC > was 0.50, low when the ICC < was 0.50, moderate when the ICC > was 0.50 and < was 0.75, high when the ICC > was 0.75 and < was 0.90, and excellent when the ICC > was 0.90. A 1-way repeated measures analysis of variance (ANOVA) was used to determine the differences in RT and COP velocities between two-legged stance on firm surface and one-legged stance on firm surface and foam. In addition, η^2 (Eta – squared) was used to calculate the effect sizes (f) and divided into small (f values = 0.10), medium (f values = 0.25) and large (f values = 0.40) effects (Cohen, 1988). The significance level was set at $\alpha = 5 \%$.

RESULTS

All data were normally distributed. COP velocity during BT increased from the low intensity BT (33.8 mm/s; SEM = 1.06 mm/s) i.e., two-legged stance, to the high intensity BT i.e. (116 mm/s; SEM = 9.23 mm/s), one-legged stance on the compliant surface ($F_{1,19,22.5}=75.0$; $p=0.001$; $\eta^2=0.79$; Table 1). Accordingly, the moderate intensity BT i.e., one-legged stance on a firm surface resulted in a 123.6 % increase in COP velocity compared to the two-legged stance. As

expected, postural control was even more demanding during high-intensity BT, as COP velocity increased by $244.2 \% \pm 111 \%$ ($P < 0.001$). On the other hand, there were no differences in RT measurements during BTs of different intensities ($F_{2,38}=0.53$; $p=0.596$; $\eta^2=0.03$).

Table 1. Centre of pressure velocity and reaction time for the respective stance and sensory conditions.

	COP velocity (mm/s)	SEM _{COPvelocity} (mm/s)	RT (ms)	SEM _{RT} (mm/s)
Low intensity BT- <i>two-legged stance</i>	33.8±4.6 [31.6, 36.0]	1.03	224.2±30.1 [238.2, 222.0]	6.73
Moderate intensity BT - <i>one-legged stance</i>	74.7±17.6*** [66.5, 83.0]	3.95	229.3±38.8 [211.2, 247.5]	8.86
High intensity BT - <i>one-legged stance on the compliant surface</i>	116.0±41.3***### [96.7,135.3]	9.23	227.2±31.8 [212.2, 241.9]	7.11

Notes. Data of COP velocity and RT are expressed in mean values \pm standard deviation [confidence interval]. BT – balance task; COP – centre of pressure; RT – reaction time; SEM – standard error of the measurement. Asterisks indicate a significant difference to the low intensity BT (** $P < 0.001$), section signs indicate a significant difference to the moderate intensity BT (### $P < 0.001$).

The repeatability of six COP velocity measurements was moderate for low intensity BT ($ICC = 0.509$) and high for moderate and high intensity BTs ($0.75 < ICC < 0.90$) (Table 2). The repeatability of six RT measurements was high for all the BTs ($0.75 < ICC < 0.90$).

Table 2. Intraclass correlation coefficients for centre of pressure velocity and reaction time for the respective stance and sensory conditions.

	ICC _{COPvelocity}	ICC _{RT}
Low intensity BT- <i>two-legged stance</i>	0.509 [0.079, 0.779]	0.887 [0.788, 0.949]
Moderate intensity BT - <i>one-legged stance</i>	0.821 [0.665, 0.920]	0.812 [0.648, 0.916]
High intensity BT - <i>one-legged stance on the compliant surface</i>	0.899 [0.810, 0.954]	0.814 [0.657, 0.918]

Notes. ICC for COP velocity and RT are expressed in mean values [confidence interval]. BT – balance task; COP – centre of pressure; RT – reaction time; ICC – intraclass correlation coefficient.

DISCUSSION

The aim of this study was to investigate the changes in simple RT to visual stimuli during BT of different intensities. We hypothesised and confirmed that reducing the base of support and decreasing the use of sensory information would increase COP velocities. Additionally, we hypothesised and declined that participant would increase their RT to visual stimuli during the more difficult posture and that the RT dual-task paradigm could be used as a surrogate for the relative intensity of the BT.

Although a statistically significant increase in COP velocity was observed when the support surface was reduced (i.e., two-legged stance vs. one-legged stance) and/or kinaesthetic input was restricted (i.e., firm vs. compliant), we found no significant differences in simple visual RT between BTs of different intensities ($p = 0.596$). The test-retest reliability of COP velocity and RT at different BT intensities showed that the intraclass correlation coefficients were good for all BTs tested, suggesting that the present results are not due to a lack of reproducibility of the postural or RT measurements. These results suggest that RT was not sensitive to the increase in COP movement when BTs were performed. Accordingly, the dual-task paradigm with simple RT to a visual stimulus could not be used as a surrogate for the relative intensity of BTs.

A significant increase in COP velocity during one-legged stance on firm and compliant surfaces confirmed that a progression of postural demands was achieved during the narrowing of the stance surface (one-legged stance) and/or during the limitation of kinaesthetic input (one-legged stance on compliant surfaces). Similar results were also reported in the study by Muehlbauer et al. (2012), in which 12 exercises were measured and 5 balance variables were analysed to recommend appropriate progression of BTs. The authors found that a change in support conditions and sensory information increased the COP displacement, which was also found in our study. They suggest that the one-legged stance is more demanding than the two-legged stance, probably due to the fact that the one-legged stance requires a longer lever arm to ensure the development of appropriate balance corrections to counteract the increased instability compared to the two-legged stance (Sarabon et al., 2010; Muehlbauer et al., 2012). Accordingly, the centre of mass will oscillate over the natural vertical line, resulting in increased postural sway (Muehlbauer et al., 2012). In addition, greater activation of the peroneus longus, soleus and tibialis anterior was observed to stabilise the body in the one-legged stance compared to the two-legged stance (Amiridis et al., 2003), which further supports the assumption of higher and more complex postural demands in the one-legged stance compared to the two-legged stance. The additional increase in COP velocity during one-legged stance on the compliant surface (i.e., high intensity BT) compared to one-legged stance on firm

surface could be related to the greater instability caused by the compliant surface, as it causes a greater increase in anterior–posterior and mediolateral instability compared to a firm surface.

Although statistically significant differences in COP velocity confirmed an increase in the intensity of BT, this increase was not confirmed by RT measurements during BTs. On contrary, Teasdale et al. (1992, 1993) reported that young and older individuals, when asked to maintain an upright, stable posture, had slower RT to an auditory stimulus when sensory information was reduced. Similarly, Lajoie et al. (1993) confirmed a non-significant small increase in RT to a visual stimulus when the base of support was reduced during the BT. Their observation suggests that maintaining and regulation of posture requires considerable information processing capacity and that a more difficult BT may require a greater proportion of available attentional resources. However, in our study, RT remained virtually the same regardless of the BT performed. It seems that our participants were able to focus their attention on the RT so that it remained practically the same, while a significant increase in COP velocity was observed (Verghese et al., 2007; Yogev-Seligmann et al., 2010). It appears that the dual-task conditions used in our study were not demanding enough for our participants to limit attentional capacity for RT performance, regardless of the intensity of the BTs. Indeed, attentional focus has previously been shown to affect postural control and RT performance only when the dual-task conditions are demanding enough (Remaud et al., 2013). However, it is possible that our participants focused their attention on RT measures because the BT were not demanding enough. Indeed, the distribution of attentional capacity between tasks has been shown to depend on various factors, such as the complexity of the tasks, familiarity with them, and their perceived importance (Chipunza & Mandeya, 2005). On the other hand, we could speculate that the simple visual RT in our protocol did not require a sufficient load on a cognitive system, resulting in no differences in RT measured at one-legged stances. Similarly, Jehu et al. (2016) found in their study that there were no statistically significant changes in simple RT during BT, while statistically significant changes in choice RT were observed during BT. Accordingly, simple RT to a visual stimulus measured during BT could not be used as a surrogate for the relative intensity of BT.

Our study has several limitations. First, we only measured simple RT and did not include measurements of choice RT. In addition, RT was not measured in the sitting position prior to the start of the protocol. Such a measurement would serve as a baseline measurement of RT and would allow a more detailed comparison of RT between low and high intensity BT. Another limitation is that we only included young, healthy recreational athletes for whom the selected

BT were not challenging enough; therefore, it would be more optimal to increase the difficulty level of BT in further studies. Another limitation is the assumption that all participants had the same maximal balance ability and that the same balance task presented the same balance challenge for all participants. In future studies, it would also be useful to include a larger sample of participants.

In our study, we assumed that the simple RT evoked by a visual stimulus can determine the relative intensity of BT. The study results did not confirm our assumptions about the prolongation of RT with increasing BT intensity, but rather indicated a redistribution of attentional focus. This means that simple RT cannot be used as a relative measure of the intensity of BT. In future studies, it would be useful to investigate whether the choice RT can be used as a measure of the relative intensity of balance training, as it is essential for the dosage prescription and thus for the effectiveness of balance training.

CONCLUSION

When prescribing balance training, it is essential to determine the dose. For balance training, the three most commonly cited parameters are frequency (recommended: 2-3 times/week), type of tasks (static and/or dynamic task) and duration (recommended: 45-60 minutes) (Lesinski et al., 2015; Espy et al., 2017; Farlie et al., 2016), while BT intensity as a relative measure remains undetermined in the current literature. In our study, participants performed three BT, categorized into low, moderate and high intensity. COP velocity and simple visual RT elicited by a light stimulus, were evaluated. RT can be used as a baseline measure of the engaged attentional capacity required to perform the task (Yogev-Seligmann et al., 2008). Contrary to our hypothesis, RT did not prolong during higher intensities of BT, despite increased COP velocity. Therefore, our study confirmed that simple visual RT cannot be used as a surrogate for relative intensity of the BT. Future studies should examine whether the choice RT can be a surrogate for relative intensity of BT, as it is necessary for the dosage and thus the effectiveness of balance training.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Cengizhan Sari^{1*}**Taylan Aytac**²**Harun Koc**³**Yusuf Buzdagli**⁴**Ozcan Esen**⁵**Raci Karayigit**⁶**ABSTRACT**

Post-activation performance enhancement is a principle that suggests that an acute bout of high intensity voluntary exercise will be followed by an improvement in strength, power, jump and speed of a subsequent task. This study aimed to investigate changes in 15 s repetitive vertical jump performance after one set (1 x 10 repetitions) or three sets (3 x 10 repetitions) of tuck jumps conditioning activity. Twelve male (age 21.6 ± 1.5 years) trained volleyball players participated in this study. The participants performed three experimental sessions with a randomized, counterbalanced, and crossover research design: a-) single set of tuck jump (SJ); b-) multiset of tuck jump (MJ); and c-) control (CON). Each experimental session was composed of a standard warm-up, conditioning activity, 5 minutes of rest, and then 15 s vertical jump test, respectively. Peak ($p=0.029$) and average ($p=0.018$) jump height, peak ($p=0.029$) and average ($p = 0.007$) power output were significantly greater in SJ than CON. No significant differences were observed in the fatigue index between conditions ($p=0.657$). Overall, there were no significant differences in any parameters between MJ and CON and between SJ and MJ ($p>0.05$). These results showed that a SJ could improve repetitive vertical jump performance in trained male volleyball players, but caution should be given while using MJ before trainings or matches including activities with repetitive jumping.

Keywords: countermovement jump; PAPE; post-activation potentiation; plyometric conditioning; volleyball

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POST-ACTIVATION PERFORMANCE ENHANCEMENT EFFECT OF TWO TUCK-JUMP PROTOCOLS WITH DIFFERENT VOLUMES ON 15-S VERTICAL JUMP PERFORMANCE**UČINEK METODE PAPE PRI DVEH PROTOKOLIH VERTIKALNIH POSKOKOV NA PARAMETRE ZMOGLJIVOSTI PRI PONAVLJAJOČIH VERTIKALNIH SKOKIH****IZVLEČEK**

Povečanje zmogljivosti po aktivaciji je načelo, ki predpostavlja, da bo po akutni seriji visoko intenzivne dejavnosti sledilo izboljšanje jakosti, moči, skoka in hitrosti pri naslednji nalogi. Namen te študije je bil raziskati spremembe v zmogljivosti ponavljajočih se navpičnih skokov v 15 sekundah po eni seriji (1 x 10 ponovitev) ali treh serijah (3 x 10 ponovitev) skokov s pritegom kolen k prsim. V raziskavi je sodelovalo dvanajst treniranih odbojkarjev (starih $21,6 \pm 1,5$ let). Udeleženci so izvedli tri eksperimentalne treninge z naključnim, uravnoteženim in križnim raziskovalnim načrtom: a-) ena serija skokov s pritegom kolen k prsim (SJ); b-) več serij skokov s pritegom kolen k prsim (MJ); in c-) kontrolna skupina (CON). Vsak eksperimentalni trening je vključeval standardno ogrevanje, specifično ogrevanje, 5 minut počitka in nato 15-sekundni test navpičnih poskokov. Najvišja ($p=0,029$) in povprečna ($p=0,018$) višina skoka, najvišja ($p=0,029$) in povprečna ($p = 0,007$) moč sta bili v eksperimentalni skupini statistično značilno večji kot v kontrolni skupini. Med različnimi pogoji ni bilo ugotovljenih pomembnih razlik v indeksu utrujenosti ($p=0,657$). Na splošno ni bilo najdenih pomembnih razlik v nobenem parametru med skupino, ki je izvajala več serij poskokov in kontrolno skupino ali med MJ in CON ter med SJ in MJ ($p>0,05$). Ti rezultati so pokazali, da lahko SJ izboljša zmogljivost ponavljajočih se navpičnih skokov pri treniranih moških odbojkarjih, vendar je treba biti previden pri uporabi MJ pred treningi ali tekmami, ki vključujejo dejavnosti s ponavljajočimi se skoki.

Ključne besede: skok z nasprotnim gibanjem, PAPE, povečanje zmogljivosti po aktivaciji, pliometrični trening, odbojka

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INTRODUCTION

The improvement of electrically evoked twitch force refers to the traditional term “post-activation potentiation” (PAP) (Robins, 2005), while more recently, the term “post-activation performance enhancement” (PAPE) has been used to specify the increase in force and power output because of voluntary contractions (Cuenca-Fernández et al., 2017). These terms describe different structures and have been used interchangeably. Although PAPE’s exact mechanism is not fully understood, there is evidence linking PAPE to an increase in intramuscular water content and muscle temperature as well as an elevation in alpha motor neuron excitability and phosphorylation of myosin regulatory light chains, which makes them more responsive to myoplasmic Ca^{2+} and acute alterations in muscle architecture such as a decrease in the pennation angle (Blazevich & Babault, 2019). It usually occurs in a 4-10 min time window after an application of a relatively high-intensity strength or speed-based exercise that is named the conditioning activity (CA) (Sale, 2002). These concepts of PAP and PAPE, and their practical applications, have gained widespread attention in the field of sport science due to their potential for optimizing athletic performance. Athletes and coaches across a diverse range of sports often incorporate these techniques into their training regimens, exploiting the short-term enhancement in muscle force, speed and jump that these methods can deliver.

Plyometric exercises have been scientifically demonstrated to increase muscle force and speed (Chu & Meyer, 2013). Fundamentally, plyometrics exploit the stretch-shortening cycle (SSC), a natural mechanism that involves the rapid transfer of force through storage and release by the body's passive structures, particularly the series elastic component (SEC) such as tendons (Komi, 2000). During the eccentric phase of a movement, these elastic components store potential energy. This energy is swiftly released as the movement transitions to the concentric phase, increasing the force and speed of muscle contractions (Cormie, McGuigan & Newton, 2011). Consequently, plyometric exercises offer a method for the targeted development of the neuromuscular system's capacity to generate force quickly and efficiently. Implementing those types of exercises as a CA in PAPE applications is one of the greatest alternatives to traditional resistance type CAs (Till & Cooke, 2009; Seitz & Haff, 2016; Turner, Bellhouse, Kilduff & Russell, 2015; Tillin & Bishop, 2009; Esformes, Cameron & Bampouras, 2010). According to Turner et al., using plyometric exercise is a beneficial technique to enhance sprint performance by inducing the PAPE (Turner, Bellhouse, Kilduff & Russell, 2015). Applications of PAPE can increase the rate of force development (Sale, 2002; Tillin & Bishop, 2009), which is essential in sports requiring high-speed outputs. A rich body of literature underlines the importance of

plyometric CA in this context, with numerous studies exploring its impact on PAPE (Maloney, Turner & Fletcher, 2014). Masamoto et al. (2003), investigated the effects of three double-leg tuck jumps and two depth jumps on subsequent 1RM squat performance, and observed an improvement in 1RM squat performance by 4,9 kg (3.5%) only after two depth jumps. McBride et al. conducted a single set of 3 repetitions of a loaded countermovement jump (CMJ) at 30% of 1RM but found no differences in 40-m sprint performance after 4 minutes of rest. In that study, authors have attributed the lack of any performance outcomes to the inadequacy of the single set for inducing PAPE. Additionally, Till & Cooke and Tsolakis et al. reported that tuck jump protocols had no effect on performance. Since these studies (Masamoto, Larson, Gates & Faigenbaum, 2003; McBride, Nimphius & Erickson, 2005; Till & Cooke, 2009; Tsolakis, Bogdanis, Nikolaou & Zacharogiannis, 2011) reported conflicting findings, further investigation is required to determine whether plyometric exercises could potentially cause PAPE. The acute response to a heavy resistance stimulus has been thoroughly researched (Tsolakis, Bogdanis, Nikolaou & Zacharogiannis, 2011; Crewther et al., 2011; Suchomel, Sato, DeWeese, Ebben & Stone, 2016), and an increasing amount of evidence indicates the possibility that plyometric ballistic exercises could also serve as an alternative PAPE method (Till & Cooke, 2009; Maloney, Turner & Fletcher, 2014). The investigation and comprehension of these mechanisms continue to be a focus of sport and exercise science research, contributing to our growing understanding of optimal performance conditioning and recovery strategies.

Utilizing PAPE prior to competition would indeed be simpler if it were done without the requirement for expensive and heavy equipment (Maloney, Turner & Fletcher, 2014). Furthermore, PAPE via plyometric exercises can be more time efficient compared to a heavy resistance stimulus because this potentiation might occur with reduced acute fatigue, allowing for more time-efficient, and hence shorter, rest periods between sets of plyometric exercises. Plyometric exercises could be a good substitute for heavy resistance type CA for PAPE if properly implemented. The number of sets, rest interval, and CA type are all significant elements for improving the performance output. Whilst fatigue develops following a CA, potentiation occurs, and the ratio of these two processes is what determines the final performance enhancement magnitude (Tillin & Bishop, 2009). Furthermore, previous research on PAPE via plyometric exercises has examined one-time performance (single vertical jump) results. (Tobin & Delahunt, 2014; Sharma et al., 2018; Krzysztofik, Kalinowski, Filip-Stachnik, Wilk & Zajac, 2021). Tobin and Delahunt (2014), reported that one-time CMJ performance improved at 1, 3 and 5 minutes after plyometric CA (total 40 jumps). Sharma et al. (2018),

demonstrated that one-time CMJ performance increased at the 10th minute after plyometric CA involving 40 jumps. Krzysztofik et al. (2021), also performed a one-time attack jump and standing spike attack performance on volleyball players with a self-selected rest intervals after plyometric CA (total of 15 jumps). As a result, researchers found no acute performance improvement. However, especially in team sports such as volleyball, handball and basketball, repeated jumps take place instead of a single jump (Okuno et al., 2013; Peña, Moreno-Doutres, Coma, Cook & Buscà, 2018). Thus, single-time performances do not fully reflect the repetitive, intermittent, and high-intensity nature of team sports. 15 seconds of continuous CMJs may not directly replicate the intermittent jumping patterns typically observed in these sports, where jumps are followed by limited recovery periods. However, our selection of the continuous 15-s CMJ test was based on the desire to investigate maximum jump performance over a short period of time, which is a crucial aspect of performance in a variety of sports such as volleyball, handball, and basketball. Continuous jumping tests have been widely used in the literature as they are excellent for assessing maximum jump performance over a short period of time (Del Coso et al., 2012; Nikolaidis, Ingebrigtsen, Póvoas, Moss & Torres-Luque, 2016) and it can be proposed that they still hold value as an indirect measure of an athlete's potential performance in sports. While we acknowledge the deviation from exact game conditions, we argue that this method presents a novel approach to exploring performance enhancement mechanisms. This could inspire future research which more closely aligns with the activity patterns of team sports such as volleyball, handball, and basketball., thus bridging the gap between laboratory findings and field application. Therefore, the aim of this study was to investigate the effects of applying a single set or multiple sets of plyometric exercises on 15-s vertical jump performance. It was hypothesized that PAPE effect would be observed after single and multiple tuck jump conditioning activities.

METHODS

Study Design

A randomized, counterbalanced, repeated-measures design was used to compare the PAPE effects caused by single or multi set plyometric activities throughout three trials and to identify any possible differences between the 3 conditioning stimuli. Which protocol participants would follow on which day was determined by a simple randomization method using a random number table. On each test day, participants were divided into equal numbers and randomly assigned to

different protocols (4 participants CON, 4 participants SJ, 4 participants MJ). The first laboratory visit was used for familiarization and to perform anthropometric measurements. In the subsequent three trials, the participants performed 15-second vertical jump tests. Each session consisted of 15 s vertical jump test preceded by a CA. The conditioning stimulus were (1) a single set of jump (SJ) (1 x 10 rep.), (2) multi set of jump (MJ) (3 x 10 rep.), or (3) control (CON). Each participant completed a standardized warm-up and PAPE protocols before each trial. Following the warm-up and PAPE protocol, participants rested in seated position (passive rest) for 5 min and subsequently performed a 15 s vertical jump test (Bosco, Luhtanen & Komi, 1983). Throughout the trials, participants drank water ad libitum, and same two member of the study team conducted all tests to reduce any variance in test instruction. At the beginning of each visit, participants were made aware of the condition to which they would be exposed. All the test sessions were separated by 72 h to allow recovery. All experiments were carried out in the same laboratory, where the temperature was fixed and kept between 21 ± 2 °C at the same time of day (3:00 p.m./4:00 p.m.) to control the effects of the circadian rhythm. In addition, participants were instructed to refrain from eating two to three hours before each testing session. All participants were asked to wear appropriate running shoes and had the same training gear (t-shirt, shorts, and socks) to reduce the potential for variation in the test design.

Participants

The number of required participants was determined with the G*Power software (3.1.9.7 version, University Dusseldorf, Germany). For the analysis, the following parameters were assumed: an effect size (ES) of 0.20 for a vertical jump; an alpha level of 0.05; overall effect size 0.85; r of 0.90; 1 group and 3 measures (Krzysztofik, Kalinowski, Filip-Stachnik, Wilk & Zajac, 2021). The power analysis revealed that this investigation needed a sample size of 11 individuals. To accommodate for any potential dropouts, we enrolled 12 trained males. Twelve male trained (McKay et al., 2022) volleyball players (Table 1) voluntarily participated in this study. The inclusion criteria were individuals with at least 5 years of training experience and actively playing volleyball. As exclusion criteria, participants who had any chronic disease or lower extremity injury in the last year or who needed to take medication continuously were not included in the study. All athletes had 7.5 ± 2.5 years of competitive club volleyball experience and had played in regional and university-level leagues. Participants had participated in volleyball training for at least 4×2 hours per week over the past two years. All participants were instructed to adhere to their regular diet and refrain from taking any dietary ergogenic aids or stimulants during the experiment. Before giving "written informed consent" to voluntarily

participate in the study, participants were informed about the study aims, methods and associated risks. All participants were advised not to engage in vigorous physical activity and not to consume alcohol and caffeine for 24 hours prior to the measurements. This experimental protocol was approved by the Mus Alparslan University Scientific Research Ethics Committee (Approval no: 73181-12/40). The study was conducted according to the principles of the Declaration of Helsinki (1983).

Table 1. Participants' characteristics.

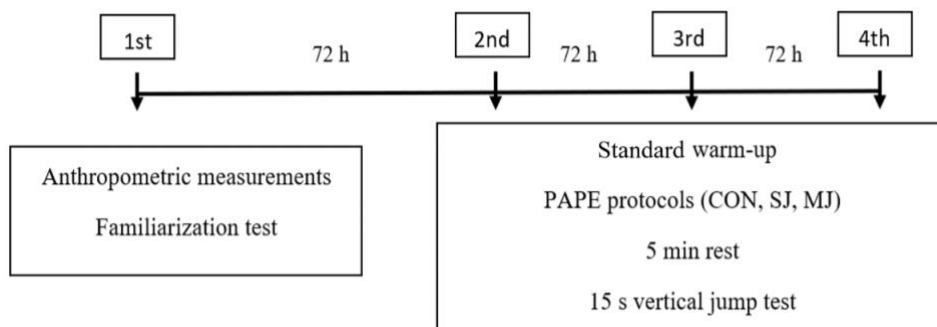
Characteristics	Mean + SD
Age (years)	21.6 ± 1.5
Body weight (kg)	70.0 ± 4.9
Body height (cm)	180.6 ± 4.7
Body mass index (kg/m ²)	21.6 ± 2.6
Body fat (%)	7.7 ± 1.8
Volleyball experience (years)	7.5 ± 2.5

Procedures

The participants attended a familiarization session one week prior to the start of the study to become familiar with the protocols and testing procedures. On the same day, anthropometric height, with a 1 mm stadiometer (Seca 213, Hamburg, Germany), and body mass measurements (Tanita Body Composition Analyzer MC-780MA, Tokyo, Japan) were obtained. 15 second vertical jump test was used to assess the participants' jump height, and, for the first time in the literature, fatigue index which is relevant to team sports where quality in consistency of repetitive jumping can be an advantage in gaining an edge over the opponent. Upon each visit, participants first warmed up by running on a treadmill at a constant speed of 6,5 km/h for 5 minutes. Then, they performed dynamic stretches for 2 minutes. The dynamic exercises, each consisting of 10 repetitions, included the following movements: Knee to chest calf raises; heel to hip calf raises; external rotation with calf raises to the hip; hamstring stretch half step forward. Participants were warned not to do static stretching, jumping, and short sprint runs during dynamic stretching period. After an active recovery with 2 min by walking, PAPE protocols were performed. Following a 5 min passive rest, 15 second vertical jump test was then conducted. The design for this experimental process is illustrated in Figure 1.

Figure 1. Experimental design. CON = control, SJ = single set jump, MJ = multi set jump.

PAPE Protocols



In the SJ protocol, participants performed 10 repetitions of tuck jumps. In the MJ protocol, 3 x 10 repetitions of tuck jumps were performed, separated by 30 s rest. No preload was applied in the CON protocol. During CON protocol, participants walked continuously for 2 minutes at a modest speed (5 km/h) in order to limit temperature loss compared to the PAPE condition. Tuck jumps were performed as a fast stretch-shortening cycle action. The tuck jumps in SJ and MJ protocols started with a countermovement, which was followed by a maximum vertical jump while simultaneously bringing the knees toward the chest. Participants were verbally encouraged to attain maximum vertical displacement and minimize ground contact duration throughout each repetition (Read, Oliver, Mark, Myer & Lloyd, 2016).

15-Second Vertical Jump Test

The 15-s vertical jump tests were performed on a mobile contact mat (Smart Jump; Fusion Sport, Queensland, Australia) (Reeve & Tyler, 2013). Following a voice signal, the participants began the test in an upright position with weights evenly distributed on both feet and arms positioned at the waist. For each jump, participants squatted until their knees were bent about 90°, jumped vertically as high as possible, and landed with both feet simultaneously, repeating the jump for 15 seconds. Participants were asked to remain with their trunk in the vertical positioning with no excessive forward move, having their knees extended during the flight phase, and jump as many times and as high as possible for 15 seconds. The repeated 15-seconds jumping test procedure had as basis the description made by Bosco et al. (1983), whose reliability for the continuous 15-seconds vertical jumping test has been reported as high, $r = 0.95$. Jump height, power and fatigue index (FI) were recorded. The fatigue index was obtained considering the first (HMEAN_4J) and the last (HMEAN_end4J) four jumps of the test (Maud & Foster, 2009), according to Eq:

$$\text{Fatigue Index} = [(\text{HMEAN_4J} - \text{HMEAN_end4J}) / \text{HMEAN_4J}] \times 100$$

Statistical Analyses

IBM SPSS 22.0 (IBM Corp., Armonk, New York, USA) was used in the analysis of the data. A Shapiro–Wilk test was used to confirm normal distribution. The 15 s vertical jump performances were evaluated using one-way repeated measures ANOVA. Mauchly’s test analyzed the sphericity assumption followed by the Greenhouse–Geisser adjustment if required. If significant interactions or main effects were detected, pairwise comparisons with Bonferroni’s corrections were applied. For each paired comparison, Cohen’s *d* effect sizes were calculated, which range from trivial ($d < 0.20$); small (d between 0.20 and 0.49); moderate (d between 0.50 and 0.79) and large ($d \geq 0.80$) (Cohen, 1992). To assess the test–retest consistency of the three test sessions, intraclass correlation coefficients (ICC) were obtained and interpreted as follows: poor reliability: < 0.5 , moderate reliability: 0.5–0.75, good reliability: 0.75–0.90, and excellent reliability: > 0.90 (Portney & Watkins, 2008).

RESULTS

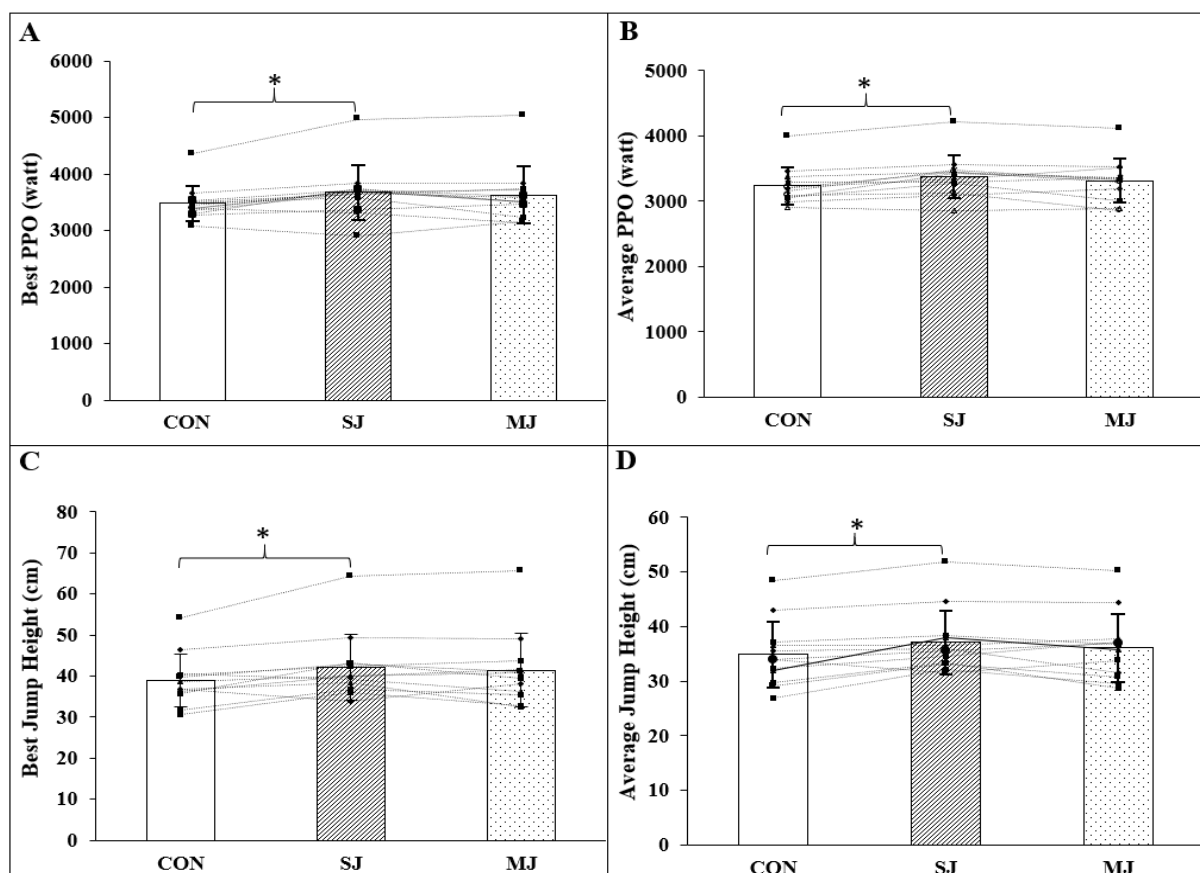
Table 2 shows the peak and average jump height, power output and fatigue index (%). There was a statistically significant difference between the PAPE protocols in the peak jump height ($F = 5.464$; $p = 0.012$), average jump height ($F = 5.554$; $p = 0.011$), the peak power output ($F = 5.452$; $p = 0.012$) and average power output ($F = 6.695$; $p = 0.005$). The Bonferroni post hoc test showed that single set of tuck jump protocol improved performance compared to control in the peak jump height ($p = 0.029$; $d = 0.44$), average jump height ($p = 0.018$; $d = 0.38$), the peak power output ($p = 0.029$; $d = 0.48$), and average power output ($p = 0.007$; $d = 0.46$) (Figure 2). There was no significant difference in fatigue index ($F = 0.428$; $p = 0.657$) (Table 2). ICC values are 0.96 for peak jump height, 0.97 for average jump height, 0.95 for peak power output and 0.96 for average power output which means 15 seconds vertical jump test performed with excellent reliability.

Table 2. 15 s vertical jump parameters after PAPE protocols (n = 12).

	CON	SJ	MJ
Parameters		Mean ± SD (Δ (%))	
The peak jump height (cm)	38.93 ± 6.31	42.16 ± 8.05*	41.37 ± 8.93
Δ (%)	-	+ 8.2	+ 6.2
Average jump height (cm)	34.88 ± 5.99	37.15 ± 5.82*	36.12 ± 6.21
Δ (%)	-	+ 6.5	+ 3.5
The peak PO (W)	3479.61 ± 313.02	3675.58 ± 483.50*	3627.61 ± 500.82
Δ (%)	-	+ 5.6	+ 4.2
Average PO (W)	3233.91 ± 89.10	3379.19 ± 330.31*	3313.52 ± 337.33
Δ (%)	-	+ 4.4	+ 2.4
FI (%)	13.28 ± 8.54	12.26 ± 8.41	12.91 ± 7.03
Δ (%)	-	- 7.6	- 2.7

CON = control; SJ = single set jump; MJ = multi set jump; PO= power output; FI = fatigue index; SD = standard deviation; Δ (%): percentage change according to CON. *: p<0,05 compared to CON.

Figure 2. 15 s vertical jump parameters after PAPE protocols; PO: power output, CON: control, SJ: single set jump, MJ: multi set jump; *: SJ was significantly different than CON.



DISCUSSION

The aim of this study was to compare the impact of performing one set (1x10) versus three sets (3x10) of plyometric CA on 15 s CMJ performance. Our results demonstrated that after solely one set of plyometric CA, both peak and average jump height, peak and average power output were considerably higher than in the control trial. Multi-set plyometric CA did not improve 15 s CMJ performance. The fatigue index also did not differ significantly between trials. Further, no differences were observed between one and three sets of plyometric CA.

To our knowledge, this is the first study to use plyometric CAs with different repetition numbers and repeated CMJ testing to assess the effect of PAPE. Jumping occurs multiple times rather than just once in team sports like volleyball, basketball and handball (Okuno et al., 2013; Peña, Moreno-Doutres, Coma, Cook & Buscà, 2018). As such, employing the repeated jump test for the PAPE effect is appropriate. PAPE may be more easily detectable because the 15-second vertical jump test requires multiple trials rather than a single jump. Although 15 s repetitive jump performance has not been investigated in prior PAPE investigations, the findings of this study are consistent with earlier research indicating that low-volume plyometric CAs can increase vertical jump performance (Chen, Wang, Peng, Yu & Wang, 2013; Dallas, Dallas & Tsolakis, 2019; Baena-Raya, Sánchez-López, Rodríguez-Pérez & Garcia-Ramos, 2020; Krzysztofik et al., 2022). Chen et al. (2013), tested male volleyball players using drop jump CA with one or two sets of 5 repetitions (1 min rest between sets) and reported that CMJ enhanced after applying CA in both treatments. In another study (Dallas, Dallas & Tsolakis, 2019) 2 x 5 repetitions tuck jumps improved drop jump performance in the 6th and 9th minutes. Further, the effects of various volumes of drop jump CA on the CMJ were examined by Baena-Raya et al. (2020), in which it was shown that both a single set of 5 repetitions and 3 x 5 repetitions of drop jump improved CMJ height at 4, 8, and 12 minutes, although the low volume CA (5 drop jump) had a greater effect. Lastly, Krzysztofik et al. (2022), showed an increase in jump height in the 9th minute after applying 3 x 5 tuck jumps CA in amateur male soccer players. Based on these and our findings, a low (5-15 repetitions) volume of plyometric CAs appears to be an effective stimulus for a 15 s or single vertical jump performance enhancement. The meta-analysis by Seitz and Haff, highlighted that the time required for the greatest PAPE effect may be affected by the type of CA. Specifically, the greatest PAPE effect has been reported to occur 0, 3–4 minutes after a plyometric CA, while it takes at least 5 minutes for conventional high- and moderate-intensity resistance exercises (Seitz & Haff, 2016). It has been suggested that a high level of individualization is needed in complex and equipment-required

CA designs such as heavy resistance exercises (Comyns, Harrison, Hennessy & Jensen, 2006; Weber, Brown, Coburn & Zinder, 2008; Bevan et al., 2010; Nibali, Mitchell, Chapman & Drinkwater, 2011). Therefore, such CA designs may not be practical in team sports. Eleven out of twelve participants in the present study produced a positive response to a single set of plyometric CA, resulting in a significant enhancement in 15 s repetitive vertical jump performance. Our finding offers the application of a single set of plyometric CA as a practical and appropriate method for practitioners when attempting to exploit the PAPE phenomenon.

Multi-set CA did not increase 15 s vertical jump performance in our study. This multiple-set CA may have caused fatigue and thus blunted the potential of PAPE. However, percentage increases were observed in all vertical jump parameters in multi-set CA compared to control trial (~4%) and these percentage increases were very close to the single set CA (Table 2). There was also no statistically significant difference between the sessions, based on the FI findings. Consistently, Esformes et al. (2010), reported that CMJ performance did not differ following a series of plyometric exercises (1 set 6 repeat, alternate speed bounds, right leg speed hops, left leg speed hops, and vertical bounds, 15 s rest interval, total 24 jumps). Authors have attributed this lack of effect to the potential metabolic fatigue that likely occurred due to the fact that the duration of the plyometric exercises (~70 seconds) was too long. Interestingly, Till and Cooke (2009), reported that five-tuck jumps had no meaningful effect on CMJ performance. This may be because the volume of the stimulus was too low to generate a PAPE response for participants. Collectively, these findings indicate the importance of the volume of plyometric CA as it might cause either potentiation or fatigue (Hanson, Leigh & Mynark, 2007; Khamoui et al., 2009). It is also important to highlight that whether CA volumes elicit PAPE or fatigue depends on the individual's strength level. From the present literature, it is not yet clear to determine how the individual's strength level dictates the PAPE response following plyometric CAs. Therefore, future research that addresses this uncertainty is needed. Furthermore, while volume appears to be a factor influencing PAPE responses, it should be evaluated with the intensity and/or type of plyometric CA (Seitz & Haff, 2016). Each type of plyometric CAs may induce different PAPE mechanisms of actions, in turn, overall various outcomes (Brink, Constantinou & Torres, 2023). In this regard, further research is required to investigate PAPE effects of various forms of plyometric CA (tuck, drop etc.) on vertical jump performance.

There are several other factors that can influence the effect of PAPE. Studies have indicated that recovery times following CA may impact the PAPE response, and that these optimal rest intervals may also depend on the strength level of individuals (Hamada, Sale, Macdougall &

Tarnopolsky, 2000; Chiu & Barnes, 2003; Seitz & Haff, 2016; Blazevich & Babault, 2019). It is likely that why the multi-set CA (3 x 10 reps) in this research was unable to improve jump performance was attributable to the short recovery time after CA. There is evidence to suggest that the longer the rest period, the greater the effect of plyometric CA on the vertical jump performance (Sharma et al., 2018). However, the literature is still too limited and therefore further research is required to assess and determine the optimal resting time following plyometric CA. Moreover, team sports, in particular, require repeated rapid actions as opposed to a single intense activity. The majority of past PAPE research has focused solely on single-performance outcomes (Tobin & Delahunt, 2014; Krzysztofik, Kalinowski, Filip-Stachnik, Wilk & Zajac, 2021; Sari, Koz, Salcman, Gabrys & Karayigit, 2022). One-off performances do not adequately reflect the repetitive, intermittent, and high-intensity nature of team sports. As such, evaluating PAPE's effect on repetitive jumps, sprints, changes of direction, or test batteries specific to sports branches can be more realistic when it comes to investigating its effects on real-game performance in terms of its applicability.

The present study has various limitations that should be addressed when interpreting the findings. Although the single set of tuck jump protocol enhanced 15-s repetitive vertical jump performance, exact mechanisms cannot be explained. Future studies should include the measurement of skin surface temperature or viscoelastic muscle properties during investigating plyometric conditioning activities on vertical jumping performance. Furthermore, our participants were regional and university level volleyball players. Therefore, the results may not directly transfer to elite level athletes. It should not be ignored that in our trial, a single 5-minute rest interval was provided. Different rest intervals (10 or 15 minutes) may need to be examined, as participants' strength levels and responses to CA may differ. While CA for PAPE is associated with enhanced performance, it should be kept in mind that other physically, physiological and psychological factors may play a role in determining performance. Due to the potential for individual characteristics of participants such as height, body mass, BMI, and personal training programs to influence vertical jump performance, individual characteristics should be considered when evaluating plyometric CAs and subsequent vertical jump performance. More research is needed to determine whether the plyometric CAs applied in this study will affect more specific and technical movement patterns applied during training or competition.

CONCLUSION

Low volume single set of plyometric CA (1x10 tuck jump) with a 5-minute rest time improved 15 s repeated jump performance in trained male volleyball players, while multi-set plyometric CA did not provide a significant effect. On the other hand, it should be kept in the mind that multi-set of plyometric CA enhanced jump performance ~4% averagely (Table 2). Lastly, 11 out of 12 participants responded positively to both single and multi-set of plyometric CA. In team sports involving repetitive rapid actions, plyometric CAs, which do not require any equipment before training or competition and do not take a long time, seem to be a very practical and beneficial method for practitioners and athletes. PAPE methods should take into account participants' training status as well as individual differences.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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GRASPING INCLUSION: PERSPECTIVES FROM AFTERNOON SPORTS ACTIVITIES

ZGRABIMO INKLUZIJO: POPOLDANSKE ŠPORTNE AKTIVNOSTI

ABSTRACT

Sports activities play a key role in promoting the social inclusion of diverse abilities athletes. The study investigates the perception of social inclusion in sports among the participants of three workshops within the framework of an international project covering Croatia, Serbia, and Slovenia. The survey was answered by 94 workshop participants representing a diverse demographic with an average of more than 15 years of experience in Judo. Most of the respondents had the role of coaches or athletes (judokas) in their organizations. High-quality education for coaches and a varied selection of sports activities have proven to be key factors in promoting an inclusive environment. Additionally, respondents emphasized the importance of recognizing athletes beyond their athletic achievements and promoting a "sports for all" ethos. The findings highlight the importance of involving different stakeholders in promoting inclusion in sport.

Keywords: social inclusion in sport, sports activities, coach education, diverse abilities athletes, multisectoral approach

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IZVLEČEK

Športne dejavnosti igrajo ključno vlogo pri spodbujanju socialne vključenosti športnikov raznolikih zmožnosti. Študija raziskuje percepcijo socialne vključenosti v športu med udeleženci treh delavnic v okviru mednarodnega projekta, ki zajema Hrvaško, Srbijo in Slovenijo. Na anketo je odgovorilo 94 udeležencev delavnice, ki predstavljajo raznoliko demografsko skupino s povprečno več kot 15-letnimi izkušnjami v judu. Največ anketirancev ima v klubu vlogo vaditeljice / vaditelja ali športnice /športnika. Ugotovitve poudarjajo pomen vključevanja različnih deležnikov pri spodbujanju vključevanja v šport. Kakovostno izobraževanje vaditeljev in pester izbor športnih aktivnosti sta se izkazala kot ključna dejavnika spodbujanja vključujočega okolja. Poleg tega so anketiranci izpostavili zavedanje, ki športnico / športnika kot človeka postavlja pred zgolj njene / njegove športne dosežke in pomembnost poudarka na etosu "šport za vse".

Ključne besede: socialno vključevanje v športu, športne aktivnosti, usposabljanje vaditeljev, raznolike zmožnosti športnikov, več-sektorski pristop

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INTRODUCTION

Engagement in sports activities is crucial for creating inclusive and equitable societies. As highlighted by numerous researchers, sports activities play a vital role in enhancing the social inclusion of individuals with diverse abilities. Moss and colleagues (2017) note that participation in sports activities positively influences health, self-confidence, and social inclusion. Accessible and adapted exercise options, along with tailored sports activities, significantly impact the development of positive self-esteem, confidence, and a sense of belonging (Hammond, 2022; Kirakosyan, 2019; McConkey et al., 2013; Scifo et al., 2019). Similarly, Louw and colleagues (2020) add that the diversity of sports activities and adapted training approaches promote social inclusion and self-respect among participants. These findings clearly indicate that social inclusion in sports activities is crucial for societal progress (Grandisson et al., 2019). Pereira et al. (2011) further emphasize the importance of sports activities in developing social networks, interpersonal relationships, and a sense of belonging among individuals with physical and mental disabilities. Alvarez & Ramirez (2018) highlight that sports activity programs that include diverse abilities can significantly contribute to reducing stigma and discrimination while promoting respect for diversity in society. In addition, current research shows that inclusive sports programs can help break down prejudice and embrace diversity. (Dyer & Sandford, 2023).

Based on previous research findings in the field of social inclusion in sport, the present study mainly investigates the perception of social inclusion in sport among the participants of three workshops within the framework of an international project that covered Croatia, Serbia and Slovenia. The goal was to find out what inclusion in sports means to inclusive judo coaches, judokas with and without additional needs, their parents, volunteers and leaders of inclusive sports activities and what is essential for them in the context of inclusive sports activities. The goal was also to gain insight into the experiences of playing sports in an inclusive manner, which will in turn enable a better understanding of the field of inclusion and the development of inclusive sports practice. In order for the relevant areas of inclusion in sport to be covered and discussed as thoroughly as possible, the research focused on the key topics highlighted in the study of the definition of social inclusion in sport (Pečnikar Oblak et al., 2023). The survey sought to understand which aspects of social inclusion in sport were most important to the respondents. The question about the concept of inclusion provided insight into which facets of inclusion they valued the most. Additionally, the survey explored the fundamental conditions necessary for the inclusion of all groups in sports, addressing the multifaceted

nature of inclusion. To evaluate various approaches to achieving inclusion in sports, the survey included a question on the best ways to implement inclusion. Previous research has highlighted the necessity of cooperation among different stakeholders for successful inclusion, a factor this survey aimed to verify. To ensure the successful development of inclusive practices, respondents were asked about areas needing improvement. Finally, several examples of good practices were presented, inviting participants to select the most effective ones.

METHODS

Data Collection

Data for this research were collected during three workshops of the ERASMUS-SPORT-2022-SSCP project, project number 101089846, acronym BE-JUDO-IN, title Be Judo Inclusive. The first workshop took place in Velika Gorica, Croatia, on March 26, 2023, the second in Ljubljana, Slovenia, on May 26, 2023, and the third in Sombor, Serbia, on October 7, 2023. Data were collected through the distribution of links to the online survey via email and social media, as well as in written form during the mentioned workshops.

Sample

Ninety-four participants from three workshops of the »Erasmus + Be Judo IN« project responded to the survey, who represented the following stakeholders: (1) coaches, instructors or (2) assistant coaches, (3) judokas, (4) volunteers, (5) parents, (6) club management, (7) sponsors/donors and (8) others unspecified. Participants came from four countries: Slovenia, Croatia, Serbia, Bosnia and Herzegovina. There were 60 % women and 40 % men. The participants' average age was 39 years, with an average of over 15 years of experience in judo.

Analysis of respondents' roles in the organization/club

The data revealed that the majority of respondents within the organization/club held the role of coach or instructor, representing 49 % of all valid responses. Judo practitioners followed next (33 % of responses). There were assistants (17 %), volunteers (10 %), parents (8 %), club management (9 %), sponsors/donors (1 %), and others (7 %). The analysis indicates a wide range of roles within the organization/club. The survey received the highest number of responses from coaches/instructors and judo practitioners. Furthermore, the presence of volunteers and parents actively involved in the organization/club's activities was relatively

high, which contributes to a better community cohesion and effective functioning of the sports organization/club.

Survey Design

The survey used in this study was designed based on key concepts addressed in the review article "Narrowing the Definition of Social Inclusion in Sport for People with Disabilities through a Scoping Review" (Pečnikar Oblak et al., 2023). The article highlights the complexity of understanding inclusion in sports, emphasizing its multidimensional nature and the importance of collaboration among all stakeholders in the process of implementing inclusion in sports.

To assess the opinions of participants in inclusive judo workshops regarding social inclusion in sports, a survey was designed with six key questions (Table 1). Five questions offered six possible responses, while one question offered eight possible responses. Participants were allowed to select from one to three responses. All statements were based on the aforementioned findings of the review article (Pečnikar Oblak et al., 2023). Two similar statements were key for two different areas: "Sport should be available to everyone, regardless of circumstances" was used in the context of »Concept«, and similarly, "Sports should be available to everyone, regardless of diverse abilities" was used in the "Areas for Improvement." Another pair of similar statements included "In inclusion, we should focus on possibilities, that is, what a person can do, and not on disability (what we cannot do)" for the area of »Concept« development, and "The focus in sports clubs should be on capabilities (what a person can do), not on disability" for the area of "Fundamental Conditions." Similar statements differed slightly due to both respondents and data analysis.

Table 1. Most frequently selected responses in the survey

Research area	Question	Answer / Statement 1	%	Answer / Statement 2	%
Concept	Which statement best describes the concept of inclusion or involvement in sports in your opinion?	Sport should be available to everyone, regardless of circumstances.	74	In inclusion, we should focus on possibilities, that is, what a person can do, and not on disability (what we cannot do).	72
Fundamental conditions	What do you think are the basic conditions for the inclusion of all groups of people in sports?	Social inclusion in sports would work best if all actors were involved: clubs, schools, the local community, the health system, sponsors, and others who can contribute to the strengthening and development of inclusion in sports.	71	The focus in sports clubs should be on capabilities (what a person can do), not on disability.	53
Best implementation approach	What is, in your opinion, the best way to implement inclusion in sports?	Through good education of coaches.	67	Provide as diverse as possible selection of sports activities (team sports, individual sports, non-competitive focus, programs that everyone will enjoy) and different types of training programs (inclusive, adapted, specialized).	66
Necessary collaboration	Who do you think it is necessary to collaborate with for successful inclusion in sports?	It is necessary to have a multisectoral approach: cooperation of institutions, clubs, sports federations, specialized sports associations, social workers, etc.	77	The key to successful inclusion is coaches with appropriate skills, attitudes and empathy.	64
Areas -for improvement	In your opinion, what needs to be improved for successful social inclusion in sports?	In inclusion, we must realize that an athlete is above all a human being and as such is worth much more than just a medal.	78	Sports should be available to everyone, regardless of diverse abilities.	76
Best practices	Select two of your favourite good practices of social inclusion in sports from the list!	A sports organisation or other specialized organization systematically builds the common identity of athletes regardless of their abilities.	54	Inclusive sports training of diverse abilities athletes in a sports club (mixed groups).	52

The first part of the survey gathered sociodemographic data, including country of organization/club, sex, age, role in the organization/club (judoka, coach, assistant, volunteer, parent, club management, sponsor/donor, other), Years of experience in the judo club. The questions were carefully crafted to encompass various aspects of inclusion in sports, such as (1) concept, (2) fundamental conditions, (3) best implementation approach, (4) necessary collaboration, (5) areas for improvement, and (6) best practices. Each question provided multiple response options, and participants were asked to select up to three that they considered most important.

Data Analysis

The questionnaire was initially tested on a smaller group of 30 participants from inclusive judo clubs, which are project partners from Croatia, Slovenia, and Serbia. This pilot testing allowed for the identification and correction of any potential errors and ambiguities in the questionnaire. The collected data were analysed using descriptive statistics to describe the basic characteristics of the sample and inferential statistics to determine connections and differences between various groups in the online program 1KA.¹

RESULTS

Results are summarized according to above presented six key research areas. In Table 2, twelve key statements selected by respondents are presented along with the corresponding research areas from which they originate, based on the questions. Statements are sorted in descending order from the most frequently selected.

Table 2. Survey Responses, Ranked by Percentages from Most to Least Selected. Responses with more than 50 % are considered.

Research Area	Answer	Frequency	Valid	% - Valid
Areas for improvement	In inclusion, we must realize that an athlete is above all a human being and as such is worth much more than just a medal.	71	91	78
Necessary collaboration	It is necessary to have a multisectoral approach: cooperation of institutions, clubs, sports federations, specialized sports associations, social workers, etc.	71	92	77
Areas for improvement	Sports should be available to everyone, regardless of diverse abilities.	69	91	76
Concept	Sport should be available to everyone, regardless of circumstances.	70	94	74
Concept	In inclusion, we should focus on possibilities, that is, what a person can do, and not on disability (what we cannot do).	68	94	72
Fundamental conditions	Social inclusion in sports would work best if all actors were involved: clubs, schools, the local community, the health system, sponsors, and others who can contribute to the strengthening and development of inclusion in sports.	65	92	71

¹ 1KA - <https://www.1ka.si/d/en>

Best implementation approach	Through good education of coaches.	62	92	67
Best implementation approach	Provide as diverse as possible selection of sports activities (team sports, individual sports, non-competitive focus, programs that everyone will enjoy) and different types of training programs (inclusive, adapted, specialized).	61	92	66
Necessary collaboration	The key to successful inclusion is coaches with appropriate skills, attitudes and empathy.	59	92	64
Best practices	A sports organisation or other specialized organization systematically builds the common identity of athletes regardless of their abilities.	49	91	54
Fundamental conditions	The focus in sports clubs should be on capabilities (what a person can do), not on disability.	49	92	53
Best practices	Inclusive sports training of diverse abilities athletes in a sports club (mixed groups).	47	91	52

Understanding the concept of social inclusion in sports

Understanding the concept of social inclusion in sports is crucial for creating an inclusive environment that enables the participation of all groups of people in sports activities. The results of our survey showed that the majority of participants (74 %) believe that sports should be accessible to everyone, regardless of circumstances. This finding emphasizes the importance of sports accessibility for all individuals, regardless of their abilities or other limitations. Additionally, the majority of participants (72 %) emphasized that inclusion in sports should focus on possibilities, meaning what a person can do, rather than focusing on disability or limitations. This perspective aligns with the principles of positive inclusion, which focuses on enhancing the abilities and potentials of individuals rather than their limitations.

Fundamental conditions for the inclusion of all groups of people in sports

In creating an inclusive environment in sports there is of a great importance involving all stakeholders, including clubs, schools, the local community, the healthcare system, sponsors, and others, who can contribute to strengthening and developing inclusion in sports (71 %). Also, the focus in sports clubs should be on capabilities and on what an athlete can do, not on disability (53 %).

Best implementation approach

When implementing inclusion in sports, it is important to consider various approaches that enable the participation of all individuals. The majority of participants (66 %) emphasized the importance of providing a diverse selection of sports activities and training programs that cater to the needs of different groups of people. Additionally, they highlighted the crucial role of coach education in ensuring an inclusive environment in sports (67 %).

Importance of collaboration among different stakeholders for successful inclusion in sports

Successful inclusion in sports requires collaboration among various stakeholders who can contribute to creating an inclusive environment. The majority of participants (77 %) emphasized the need for a multisectoral approach, involving collaboration among institutions, clubs, sports federations, specialized sports associations, social workers, and others. Furthermore, the majority of participants (64 %) highlighted the key role of coaches with appropriate skills, attitudes, and empathy in achieving successful inclusion in sports.

Areas needing improvement for greater success of social inclusion in sports

To enhance the success of social inclusion in sports, it is necessary to examine and improve various aspects of sports activities. The majority of participants (78 %) emphasized the need to highlight the human aspect of sports, where athletes are valued as individuals beyond mere athletic achievements. Additionally, the majority of participants (76 %) emphasized the importance of exploring the benefits of training in mixed groups, which can contribute to better understanding and improvement of inclusive practices in sports.

Good practices of social inclusion in sports

Among the highlighted practices of social inclusion in sports, participants were most enthusiastic about inclusive sports training for diverse groups of athletes in sports clubs (52 %) and organizations that systematically build a shared identity among athletes regardless of their abilities (54 %).

DISCUSSION

Statement 1 from the results of our research speaks to the idea that social inclusion emphasizes human worth over medals. This is also the statement with which the largest number of respondents agreed, with a staggering 78 %. In sports social inclusion, there is a

need to move away from narrow forms of participation centered around victories and elite success (Hammond, 2022). Analysis of articles on negative phenomena in elite sports reveals that the challenges faced by athletes are often underexplored. Athletes are reluctant to discuss mental health issues among elite athletes (Souter et al., 2018). The main stressors cited include sports injuries, as well as pressure related to competitions and performance. Often, this ongoing stress does not cease even after their sports careers. Researchers further note that the physical and psychological demands imposed by the sports environment can be predisposing factors for the development of depression among athletes (Souter et al., 2018; Hill and Curran, 2016). Additionally, post-career employment issues also trigger anxiety among athletes (Shutova et al., 2019). Studies conducted on recreational athletes show that exercise can be effective in alleviating symptoms of anxiety and depression (Kelly et al., 2020).

The primary finding highlights the importance of valuing individuals beyond athletic success in social inclusion, alongside the need to address mental health issues among elite athletes, including stress from injuries, competition, and post-career anxieties, with exercise showing promise in alleviating symptoms.

Scientific research suggests that focusing on less demanding sports disciplines and non-competitive activities could enhance the success of integrating athletes with intellectual disabilities into programs (McConkey et al., 2013). As sports inclusion progresses, there's a shift in disability sports management from national disability sports organizations to mainstream sports bodies, indicating an evolution in inclusive sports governance.² The path to inclusion as a societal norm requires not only policy changes but also shifts in social attitudes, perceptions, and institutional structures (Bouttet, 2016). Acceptance of individuals with disabilities in sports facilities is not just about organization and infrastructural adjustments but is embedded in broader social norms and perceptions. Changing the inclusion paradigm requires a multisectoral approach and significant collaboration among various stakeholders,

² It is about the transfer of governance of para-sports disciplines from the auspices of the International Paralympic Committee (IPC) to world sports federations. The first federations to do so are the International Skiing and Snowboarding Federation (FIS) and the World Dance Sports Federation (WDSF). More info:

- [IPC members approve new constitution at General Assembly \(paralympic.org\) ...An aspiration for the 10 IPC Sports to separate from the IPC by the end of 2026...](#)
- <https://www.fis-ski.com/en/international-ski-federation/news-multimedia/news-2022/fis-and-ipc-approve-transfer-of-governance-of-three-para-snowsports>
- https://www.worlddancesport.org/News/WDSF/WDSF_IPC_discuss_transfer_of_governance_of_Para_DanceSport-3184

including sports organizations, government bodies, clubs, the education system, and healthcare and social services. This necessity for a multisectoral approach is corroborated by Statement 2 from our survey (77 %), as well as the essential involvement of all societal actors, clubs, schools, local communities, healthcare systems, and sponsors in creating an inclusive sports environment (Statement 6).

The so-called ecological approach to social inclusion is intriguing as it encompasses the influence of various variables on interpersonal relationships and community participation (Simplican et al., 2015). This model views (dis)ability as a product of individual, ecological, and societal factors, which is significant for our research in the context of integrating people with diverse abilities into sports. This is consistent with the findings of our study, which emphasize the need to engage in sports regardless of different abilities and circumstances (Statements 3 and 4) and the importance of focusing on possibilities rather than limitations (Statement 5).

Our respondents believe that the best way to ensure an inclusive environment in sports is through quality coach education (Statement 7). The lack of quality training, inaccessible coaching education, insufficient research in this field, and the lack of disability-specific content leads coaches to primarily learn through personal experiences, exchanging experiences with colleagues, mentoring, or trial and error (Wareham et al., 2018; Lepage et al., 2020; Bentzen et al., 2021).

Respondents highlighted that one of the best ways to implement social inclusion in sports is through a diverse selection of sports activities and training for everyone (Statement 8). Through a comprehensive review of existing literature, Moss and colleagues concluded that engaging in sports not only contributes to improving physical well-being but also serves as a powerful catalyst for personal empowerment and social integration (Moss et al., 2017). However, the same authors suggest expanding adaptive sports activities and levels of competition to promote physical activity among diverse abilities athletes beyond rehabilitation. Additionally, diverse abilities athletes often pay attention to the principles of social inclusion in sports activities, emphasizing the need to pay special attention to the messages sent and unconscious discrimination against them in promoting adapted sports activities. In this context, Statement 10 (54 %) reflects respondents' view that a good practice example is a sports organization that builds a shared identity among athletes, regardless of diverse abilities.

Statement 9 from our research findings correlates with Statement 7 and discusses the importance of good coach education. It pertains to the key role of successful inclusion being coaches with the right skills, attitude, and empathy (64 %). This implies attention to the individual needs and requirements of individuals engaged in sports activities, aligning with the need for diversity in inclusion approaches (Kiuppis, 2018) and is associated with the requirement for a diverse selection of sports activities and training for everyone and the importance of individual preferences, desires, and choices in involving individuals in sports.

With the right approach to sports, the disability community can gain greater visibility, create positive role models, and contribute to changing societal attitudes and stereotypes about disability (Kamberidou et al., 2019). Sport can serve as a platform for building an inclusive environment that promotes collaboration, equality, and respect for diversity. Additionally, researchers have concluded that accepting and including all individuals, regardless of their abilities, can contribute to a society with more compassion, understanding, and respect. To fulfil the basic conditions for the inclusion of all groups of people in sports, our respondents agreed with the statement that it is necessary to focus on abilities, what a person can do, rather than on disability (Statement 11).

As an example of good practice, the majority of respondents in our study (Statement 12) agreed that inclusive sports training for diverse abilities athletes through mixed groups in clubs is desirable (52 %). Individuals that need additional adjustment engaging in sports alongside those without adjustments achieve better results compared to participating in separate, specialised groups (Albrecht et al., 2019). The mixed-ability model can be a powerful approach to inclusion and help change the culture of sports clubs, which are typically associations focused on elite athletes and broader perceptions of diverse ability (Dyer and Sandford, 2023).

In the summary of our research, we highlight the utmost importance of recognizing individuals beyond their athletic achievements in efforts towards social inclusion, echoing the viewpoint of our respondents who emphasized **human value over medals** (Statement 1). This aligns with the necessity of addressing mental health challenges among elite athletes, as highlighted by our findings and scientific evidence (Statements 2, 3, 4, 5, 11). Furthermore, our study follows an ecological approach to social inclusion, understanding diverse ability as multifaceted and emphasizing the need for inclusion regardless of abilities and circumstances (Statements 3, 4, 5, 11). As underscored by our respondents, quality coach education

(Statements 7, 9) and diverse sports activities and training for all (Statements 8, 10, 12) are crucial in promoting social inclusion in sport. Leveraging sports as a platform for visibility and challenging stereotypes aligns with the opinions of our respondents and suggests a shift towards inclusive sports management (Statements 2, 6). Together, these insights underscore the imperative of **accepting inclusion as a societal norm, necessitating policy reforms and shifts in social relations.**

The methods used in this study were designed to provide a comprehensive understanding of social inclusion in sports, specifically within the context of inclusive judo clubs. The survey-based approach allowed us to gather detailed insights from participants regarding their perceptions and experiences of inclusion. By basing the survey questions on the review article "Narrowing the Definition of Social Inclusion in Sport for People with Disabilities through a Scoping Review" (Pečnikar Oblak et al., 2023), we ensured that our questions were grounded in established theoretical frameworks.

As with any research, study has certain limitations that may affect the interpretation of the results. One significant limitation is the relatively small and specific sample size, which was recruited from particular environments and sports activity programs. Consequently, the findings may not be fully representative of all groups with diverse abilities or other geographical regions. Additionally, the exclusive use of a survey as the data collection method may have restricted the scope and depth of our analysis, as it does not capture the full range of experiences and nuances that might be obtained through qualitative methods such as interviews or focus groups. Despite these limitations, our study offers numerous opportunities for further research in the field of social inclusion in sports. Future studies could explore the impact of different sports programs and approaches on the level of social inclusion, examining the effectiveness of various strategies to enhance it. Expanding the sample size to include a broader range of demographic groups and geographical regions would provide a more comprehensive insight into this complex issue. Moreover, future research could investigate the role of technology, adapted sports equipment, and infrastructure in promoting social inclusion in sports. By employing a mixed-methods approach that combines quantitative and qualitative data, future studies could contribute to a deeper understanding and improvement of inclusion practices in sports for all.

CONCLUSION

The survey reveals that our respondents showed the greatest interest to the topic of necessary improvements. They believe that successful implementation of inclusion in sports hinges on the quality education of coaches, as well as a wide selection of diverse sporting activities. There was also significant readiness expressed regarding the concept of inclusion and collaboration. By respondents' opinion the concept of inclusion in sports is based on the motto "sports for all", with an emphasis on the athlete's abilities rather than limitations. It underscores a foundational principle that has been debated since the advent of social inclusion in sports, yet regrettably indicates a lack of significant progress in practical application.

Regarding the need for participation in inclusion in sports, the respondents again highlighted the involvement of the entire society and the necessary support for coaches. The following are opinions on the topic of fundamental conditions for inclusion in sports and methods of implementation. They believe that the fundamental conditions for inclusion in sports entail the involvement of the entire society, emphasizing the pursuit of opportunities rather than obstacles.

Regarding best practices, they most often chose deliberate building of a shared identity regardless of diverse abilities and conducting sports training in mixed groups in mainstream sports clubs.

It is extremely interesting that respondents most often selected the statement emphasizing that the athlete is first and foremost a human being and is worth much more than just a medal. This statement is categorized under the need for improvements in inclusion in sports, alerting us to improve our attitude towards athletes in general before we can start talking about social inclusion in sports! They also emphasized that sports should be available and accessible to all regardless of diverse abilities. This statement also brings us back to the beginnings of social inclusion in sports.

Our respondents' foremost concern revolves around the dehumanization experienced by athletes, and highlight the need for sports for all. The concept of social inclusion is clear to them: "Sports for all, with an emphasis on abilities rather than obstacles!" Additionally, they recognize the pivotal role of societal engagement and advocate for enhanced coach training to foster inclusion in sports. It appears that in 2024, we are still laying the groundwork for social inclusion in sports.

In conclusion, while this study provides valuable insights into social inclusion in sports, it is important to acknowledge its limitations. The specific sample size and exclusive use of survey methodology may affect the generalizability and depth of the findings. Future research should aim to address these limitations by expanding the participant pool and employing diverse data collection methods. Exploring the impact of various sports programs, the role of technology, and the inclusion of broader demographic groups will be essential in advancing our understanding and improving inclusive practices in sports. Through continued research, we can work towards creating a more inclusive environment for athletes of all abilities.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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