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# SHARE OF MALE BODY DIMENSIONS IN FLEXIBILITY RESULTS OBTAINED BY GRAVITY GONIOMETER

# DELEŽ RAZSEŽNOSTI TELESA MOŠKIH V REZULTATIH GIBLJIVOSTI DOBLJENIH Z GRAVITACIJSKIM GONIOMETROM

## Abstract

The purpose of the study is to establish significance and relative extent of the share of male body dimensions in the results of flexibility measurement by a gravity goniometer. A battery of fifteen angular flexibility tests (using a gravity goniometer) and twenty-one measures for establishing morphological characteristics of body were used on the sample comprising 236 male subjects. Based on the body measures, the flexibility test results were evaluated by means of regression analysis and the part of the variance which could be assumed on the basis of test subjects' morphological characteristics was determined for each variable. The regression analysis showed with reasonable certainty that almost half of the angular measurements of flexibility used in the study did not have a significant share in the morphological variables. Skin folds and circumferences of body segments had the biggest share in the used flexibility tests. Even when gravity goniometer was used, the system of body morphological characteristics had the highest share in the flexibility tests for hip joint; similar shares have been observed when using linear measures. Of fifteen flexibility measures seven could be recommended for use in sports practice (three for shoulder girdle, three for trunk and one for hip joint) as they yielded reliable results, share of body morphological characteristics in them was not considerable and they were easy to use.

*Key words:* flexibility, gravity goniometer, morphological characteristics, males, regression analysis

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## Izvleček

Namen študije je ugotovitev pomembnosti in relativne velikosti deleža morfoloških značilnosti telesa moških v rezultatih merjenja gibljivosti, dobljenih z gravitacijskim goniometrom. Vzorec 236 oseb moškega spola je bil izmerjen z baterijo 15 angularnih testov gibljivosti (uporaba gravitacijskega goniometra) in z 21 merami morfoloških značilnosti telesa. Na osnovi telesnih mer so bili z regresijsko analizo ocenjeni rezultati testov gibljivosti in za vsako spremenljivko je bil ugotovljen del variance, ki ga le-te prispevajo. Regresijska analiza je pokazala, da lahko skoraj za polovico uporabljenih kotnih mer gibljivosti z veliko gotovostjo trdimo, da sistem morfoloških spremenljivk nima večjega deleža v njihovih rezultatih. Največje deleže v uporabljenih testih gibljivosti kažejo kožne gube in obsegi telesnih segmentov. Sistem morfoloških značilnosti telesa pa ima tudi pri uporabi gravitacijskega goniometra, enako kot je bilo ugotovljeno že pri uporabi linearnih mer, največji delež v rezultatih testov za ugotavljanje gibljivosti v kolčnem sklepu. Na tej osnovi bi jih lahko, izmed petnajstih uporabljenih mer gibljivosti, kar sedem priporočili za uporabo v športni praksi (tri za ramenski obroč, tri za trup in eno za kolčni sklep), saj dajejo zanesljive rezultate, morfološke značilnosti telesa nimajo večjega deleža v njih, postopki pa so priročni za uporabo.

*Ključne besede:* gibljivost, gravitacijski goniometer, morfološke značilnosti, moški, regresijska analiza.

## Introduction

The first attempts to introduce the method for measuring flexibility using a gravity goniometer can be traced back to the early 1940s and 1950s (Leighton, 1955). The then studies of its applicability yielded some encouraging results and practical use showed that gravity goniometer was a handy and undemanding measuring device. Despite all that it was not widely used. The studies using the gravity goniometer were rare and in most cases they examined just individual joints of the body (Petherick & Rheault, 1988; Rothstein, Miller & Roetteger, 1983). That is why we were unable to find a lot of relevant information about the share of the test subjects' body morphological characteristics in the results of flexibility measuring obtained by the gravity goniometer. In some early studies a more significant share of the body measures in the results could not be established, whereas some other studies reported only on a greater share of subcutaneous fatty tissue. Some studies relating to this topic were conducted to determine somatotypes and to establish a relation between somatotypes and flexibility but the authors do not report on the applicability of the gravity goniometer. Kos (1965) was the first researcher to report on a high reliability of the results of flexibility measuring carried out with the gravity goniometer (Kapelan's fluid goniometer filled with oil), with the exception of the trunk rotations, but he does not mention the share of morphological characteristics of the test subjects' bodies in the results of measuring. In her extensive research on flexibility, using Leighton' flexometer, Harris (1969) also emphasized a high reliability of the instrument but did not establish any relation with body measures.

When checking the basic measurement characteristics of two different gravity goniometers (the fluid-based one and the builder's one), Agrež and Pistotnik (1987) also established a good applicability of both measuring instruments, but an adapted builder's goniometer proved more suitable, because it was lighter and easier to use. In his studies, which were based on the linear flexibility measures results, Pistotnik (1989, 1991) established a considerable share of morphological characteristics, but the angular flexibility measures were less influenced by them. To my knowledge the latest study conducted in this field was carried out by Pinter (1996), who established a significant influence of selected female body morphological characteristics on the majority of angular flexibility measures, but the influence of the body longitudinal measures on the results was much smaller than in the case of linear flexibility measures. Therefore, our aim is to establish to what extent the morphological characteristics of male body can affect the flexibility measuring results obtained by a gravity goniometer.

## Method

## Participants

The random sample comprised 236 male students of the University of Ljubljana aged between 21 and 22 who attended obligatory physical education for students. This age guarantees that measuring is carried out in a stable state of physical development, since physical development is complete at the age of 19 or slightly later and the processes of deterioration have not yet started.

## Instruments

The ranges of fifteen motions in the shoulder girdle, trunk and hip joint were measured with an adapted builder's gravity goniometer (five measures for each segment are described in Table 1). The information about the characteristics of the test subjects' bodies was obtained by measuring twenty-one body dimensions (see Table 2).

**Table 1:** The abbreviations of the flexibility tests - MFGS BSP: M = motorics, F = flexibility, G = gravity goniometer, S = shoulder; T = trunk, H = hip joint

| *Motion (movement) task* | *Abbreviations* |
|---|---|
| arms held backwards, sideways, prone | MFGS BSP |
| arms held backwards, upwards, prone | MFGS BUP |
| arms held upwards inward, sideways, standing | MFGS USS |
| arms held backwards, downwards, prone | MFGS BDP |
| arms held forwards inward, prone over the box | MFGS FIP |
| trunk-bending to the right, standing | MFGT RBS |
| trunk-bending forwards on the bench | MFGT BFB |
| trunk-bending forwards beside the wall bars | MFGT BFW |
| trunk-bending forwards in forward split | MFGT BFS |
| arch, kneeling | MFGT ARK |
| leg held forwards, back lying | MFGH HFL |
| leg held backwards, standing | MFGH HBS |
| leg held sideways, side lying | MFGH HSL |
| leg held forwards inward, standing | MFGH FIS |
| forward straddle | MFGH FS |

*For a more detailed description of the measures see Pistotnik (1991)*

**Table 2:** The abbreviations of the morphological characteristics

| *The abbreviations of the morphological characteristics* | |
|---|---|
| ABH – body height | ABM – body mass |
| ASH – sitting height | AWC – waist circumference |
| AAL – arm length | ACHC – chest circumference |
| ALL – leg length | AUAC – upper arm circumference |
| ASSSF – subscapular skin fold | AUACM – upper arm circumference, maximal |
| ASSF – stomach skin fold | ATC – thigh circumference |
| ASISF – suprailiacal skin fold | ACC – calf circumference |
| AUASF – upper arm skin fold | ABAS – biacromial span |
| ATSF – thigh skin fold | ABCS – bicristal span |
| ACSF – calf skin fold | AED – elbow diameter |
| | AKD – knee diameter |

*For a more detailed description of the measures see Pistotnik (1991)*

## Procedure

Reliability of flexibility tests and morphological characteristics of the male sample of this age group was established (Alvey, 1980) and was successfully proven, without any substantial peculiarity (Pistotnik, 1991). In view of the fact that the share of test subject's body morphological characteristics in the flexibility measuring results had to be determined, the procedure of deconstructing the results variance was carried out. On the basis of body measures, the flexibility tests results were assessed with the partial regression method and the part of its variability which could be assumed on the basis of morphological characteristics was established for each variable (Bala, 1986).

## Results

On the basis of the regression analysis, it may be asserted with great certainty that almost one half of angular flexibility measures which were applied where the gravity goniometer was used were not significantly connected with the system of anthropometric variables. Some of the angular measures that were used were partially connected to individual body characteristics.

Only two of five measures for the determination of the shoulder girdle flexibility had a significant share in the anthropometric variables system; this share is significant on the possibility level of less than 1% mistake, if this statement is considered true (see Table 3).

Among the measures for the determination of the shoulder girdle flexibility the system of anthropometric variables has the greatest share in the measure MFGS FIP (arms held forwards inward, prone over the box; Q = .0000), where as much as 22.95% of its variance (DELTA) is accounted for. Total variance is explained especially with the help of some skin folds and body mass: ASISF (suprailiacal skin fold) and ATC (thigh circumference) in the positive direction as well as ABM (body mass) and ATSF (thigh skin fold) in the negative direction.

The measure MFGS BDP (arms held backwards, downwards, prone) is also connected with the system of anthropometric variables to a slightly but not essentially lesser degree. The body measurements explain 18.94% of the variance of this test, which indicates a high level of certainty concerning the share of predictors in it (Q = .0010). On the whole, total variance of predictors and of criterion variable is significantly defined by some skin folds and the calf circumference (ACC). Skin folds show a different tendency regarding the share in the result, which depends on the part of the body where they are. The thigh skin fold (ATSF) has a negative share in the result. The suprailiacal skin fold (ASISF) and the subscapular skin fold (ASSSF) have a positive share in the results.

The remaining three measures for the determination of the shoulder girdle flexibility, where the gravity goniometer was used, did not show significant relation to the system of anthropometric variables, whereas the measure MFGS BUP (arms held backwards, upwards, prone) showed no connection whatsoever with individual predictors.

The next two measures MFGS BSP (arms held backwards, sideways, prone) and MFGS USS (arms held upwards inward, sideways, standing) show a significant positive relation to the predictor ASH (sitting height; Q-BETA = .01 or .03 and a noticeable negative relation to the predictor AED (elbow diameter), whose level of risk is higher and still acceptable but already exceeded (Q-BETA = .08 or .10).

**Table 3:** Relations between anthropometric variables and the shoulder girdle flexibility measures

| TEST | RO | DELTA | Q | PREDICTOR | R | PART-R | BETA | Q-BETA | P |
|---|---|---|---|---|---|---|---|---|---|
| MFGS BSP | .32894 | .10820 | .2278 | **ASH** | .20577 | .16961 | .27029 | **.0128** | **5.56** |
| | | | | AED | -.05369 | -.11830 | -.16056 | .0835 | 2.86 |
| | | | | AWC | .00314 | .10403 | .22655 | .1283 | 0.07 |
| MFGS BUP | .32176 | .10353 | .2788 | AUACM | .09470 | .12750 | .30854 | .0620 | 2.92 |
| | | | | ASSF | -.07024 | -.11714 | -.20288 | .0866 | 1.42 |
| | | | | ASH | .00214 | .09125 | .14430 | .1825 | 0.03 |
| MFGS USS | .31057 | .09645 | .3684 | **ASH** | .15745 | .14319 | .22871 | **.0359** | **3.60** |
| | | | | AED | -.06348 | -.10394 | -.15004 | .1080 | 0.95 |
| | | | | AUASF | -.02048 | -.09558 | -.14880 | .1626 | 0.03 |
| MFGS BDP | .43519 | .18939 | .0010 | **ACC** | .12742 | .22913 | .41066 | **.0007** | **5.23** |
| | | | | **ATSF** | -.06236 | -.19155 | -.31311 | **.0048** | 1.95 |
| | | | | **ASISF** | .12368 | .13436 | .19949 | **.0491** | 2.47 |
| | | | | ASSSF | .10013 | .13253 | .21325 | .0523 | 2.13 |
| MFGS FIP | **.47906** | **.22950** | **.0000** | **ASISF** | .11734 | .20027 | .29320 | **.0032** | **3.44** |
| | | | | **ABM** | -.02013 | -.15932 | -.61921 | **.0194** | 1.25 |
| | | | | **ATC** | .03958 | .15731 | .24702 | **.0210** | 0.98 |
| | | | | **ATSF** | -.06785 | -.15084 | -.23867 | **.0270** | 1.62 |

*Legend:*
RO – coefficient of multiple correlation; DELTA – coefficient of determination; Q – significance level of multiple correlation coefficient; R – coefficient of linear correlation (separate flexibility measure and body measures); PART-R – coefficient of partial correlation (separate flexibility measure and body measures); BETA – standardized coefficient of partial regression; Q-BETA – level of BETA coefficient characteristics; P – relative contribution of a separate body measure to explanation of a share in flexibility measure results

The measures for establishing trunk flexibility, for which the gravity goniometer was used, neither showed any considerable relation with the system of anthropometric variables, since only two of them share their variances with it on a significant level (see Table 4). The anthropometric variables represent the bulk of the MFGT BFW test (trunk-bending forwards beside the wall bars), where they account for 19.27% of the variance, which is significant (Q = .0008). The suprailiacal skin fold (ASISF) is the predictor that determines total variance of this test with a criterion variable to the greatest extent (P = 8.21%). It is followed by: chest circumference (ACHC), leg length (ALL), body height (ABH) and bicristal span (ABCS), each of them with its significant contribution.

The second measure of the trunk flexibility that shows considerably the share of anthropometric variables is trunk-bending forwards on the bench (MFGT BFB). The used system of anthropometric variables explains 17.96% of the criterion variable variance. At the level of reliability with a possibility of mistake below five percent, the total variance is determined solely by the measures of subcutaneous fatty tissue. These are the ATSF (thigh skin fold) and ASSSF (subscapular skin fold) measures which are substantially and negatively correlated with the forward bend on the bench as all other measures of skin folds.

**Table 4:** Relation between anthropometric variables and trunk flexibility measures

| *TEST* | *RO* | *DELTA* | *Q* | *PREDICTOR* | *R* | *PART-R* | *BETA* | *Q-BETA* | *P* |
|---|---|---|---|---|---|---|---|---|---|
| MFGT RBS | .30110 | .09066 | .4510 | **ABAS** | -.10528 | -.17854 | -.23189 | **.0087** | **2.44** |
| | | | | ACC | -.02218 | -.09859 | -.18308 | .1496 | 0.41 |
| **MFGT BFB** | **.42383** | **.17963** | **.0023** | **ATSF** | -.24171 | -.18127 | -.29750 | **.0077** | **7.19** |
| | | | | **ASSSF** | -.19230 | -.13532 | -.21915 | **.0475** | **4.21** |
| | | | | ATC | .02556 | .10392 | .16718 | .1288 | 0.43 |
| **MFGT BFW** | **.43903** | **.19274** | **.0008** | **ASISF** | .19188 | .27989 | .42806 | **.0000** | **8.21** |
| | | | | **AOPK** | .15617 | .18234 | .30276 | **.0073** | **4.73** |
| | | | | **ACHC** | .02074 | .18025 | .39736 | **.0081** | 0.82 |
| | | | | **ABH** | -.01341 | -.14747 | -.42247 | **.0307** | 0.57 |
| | | | | **ABCS** | -.09516 | -.13621 | -.16065 | **.0461** | 1.53 |
| MFGT BFS | .31885 | .10167 | .3010 | **AAL** | -.07424 | -.16539 | -.35157 | **.0152** | **2.61** |
| | | | | AKD | -.06891 | -.13277 | -.18250 | .0519 | 1.26 |
| | | | | ABH | .01782 | .11266 | .33891 | .0994 | 0.60 |
| MFGT ARK | .26271 | .06902 | .7751 | ASSSF | .05242 | .11878 | .20448 | .0823 | 1.07 |
| | | | | AWC | -.06025 | -.10137 | -.17860 | .1385 | 1.08 |
| | | | | ASH | .06261 | .08863 | .14279 | .1955 | 0.89 |
| | | | | ACC | .06167 | .08842 | .16595 | .1966 | 1.02 |

*Legend:*
RO – coefficient of multiple correlation; DELTA – coefficient of determination; Q – significance level of multiple correlation coefficient; R – coefficient of linear correlation (separate flexibility measure and body measures); PART-R – coefficient of partial correlation (separate flexibility measure and body measures); BETA – standardized coefficient of partial regression; Q-BETA – level of BETA coefficient characteristics; P – a relative contribution of a separate body measure to explanation of a share in flexibility measure results

It can be asserted with a great certainty that the other three measures of trunk flexibility are not affected by the chosen battery of anthropometric variables, since the battery explains less than 10% of their variance. The MFGT ARK measure (arch, kneeling), however, is not affected by any individual predictor, which can lead to the conclusion that the result of this test is quite realistic, since it is not importantly contaminated with body measures (DELTA = .069). In the MFGT RBS test (trunk-bending to the right, standing), only one body measure, biacromial span - ABAS (0.8% of the mistake possibility), explains the total variance of the predictor variable system, which means that the test subjects with a greater biacromial distance achieved worse results in this test.

The measure of the trunk flexibility MFGT BFS (trunk-bending forwards in forward split) is also characterized by about 10% of the total variance which is explained by anthropometric variables. The assessment of this share does not have a very solid basis, since there is a chance of mistake of not less than 30%, if this hypothesis is accepted. We could, therefore, claim that this measure is not significantly affected by the system of anthropometric variables. Among individual body measures only the AAL measure (arm length) explains the part of the total variance with the criterion variable (Q-BETA = .01) with a suitable degree of certainty. With a slightly greater risk (Q-BETA = .05) we can make a similar assertion also for the AKD predictor (knee diameter).

The system of anthropometric variables had the greatest share in the tests for establishing the hip joint flexibility not only when the gravity goniometer was used but also in the case of linear measures. As many as four of five measures were considerably related to it (see Table 5). The only measure that was not significantly affected by the anthropometric variables as a system was MFGN FS (forward straddle). It is true that body measures explain 11.26% of its variance, but this is significantly below the level that could lead us to the conclusion about their real share in the criterion variable (Q = .1860). Neither of predictors explains the significance of total variance with this measure of the hip joint flexibility. To the greatest degree, it is explained by ASH (sitting height) and ATSF (thigh skin fold) although the risk is higher (7%).

**Table 5:** Relation between anthropometric variables and hip joint flexibility measures

| *TEST* | *RO* | *DELTA* | *Q* | *PREDICTOR* | *R* | *PART-R* | *BETA* | *Q-BETA* | *P* |
|---|---|---|---|---|---|---|---|---|---|
| **MFGH HFL** | **.38317** | **.14682** | **.0262** | **ATFS** | -.17139 | -.18429 | -.30861 | **.0067** | **5.29** |
| | | | | **AKD** | -.13186 | -.15233 | -.20464 | **.0255** | **2.70** |
| | | | | AUACR | .11985 | .13349 | .33190 | .0506 | 3.98 |
| **MFGH HBS** | **.42107** | **.17730** | **.0028** | **ABM** | -.16304 | -.20191 | -.81733 | **.0029** | **13.32** |
| | | | | **ACC** | .11917 | .16391 | .29202 | **.0161** | **3.48** |
| | | | | ASISF | .01055 | .12892 | .19269 | .0591 | 0.20 |
| **MFGH HSL** | **.38162** | **.14563** | **.0283** | **AUACR** | .01876 | .18911 | .47487 | **.0054** | 0.89 |
| | | | | AUACM | -.03536 | -.12431 | -.29357 | .0689 | 1.04 |
| | | | | ACC | .04929 | .10982 | .19790 | .1083 | 0.97 |
| **MFGH FIS** | **.37242** | **.13870** | **.0441** | **ASISF** | .19208 | .17490 | .26940 | **.0102** | **5.17** |
| | | | | **ABCS** | .01157 | .13726 | .16725 | **.0444** | 0.19 |
| | | | | AWC | -.00702 | -.10229 | -.21888 | .1349 | 0.15 |
| MFGH FS | .33555 | .11259 | .1860 | ASH | .05096 | .12255 | .19345 | .0729 | 0.98 |
| | | | | ATSF | -.14183 | -.12232 | -.20689 | .0735 | 2.93 |
| | | | | AAL | -.11546 | -.10563 | -.22133 | .1226 | 2.55 |

*Legend:*

RO – coefficient of multiple correlation; DELTA – coefficient of determination; Q – significance level of multiple correlation coefficient; R – coefficient of linear correlation (separate flexibility measure and body measures); PART-R – coefficient of partial correlation (separate flexibility measure and body measures); BETA – standardized coefficient of partial regression; Q-BETA – level of BETA coefficient characteristics; P – a relative contribution of a separate body measure to explanation of a share in flexibility measure results.

Leg held backwards, standing (MFGH HBS) is the measure of the hip joint flexibility which is significantly affected by the system of anthropometric variables. The level of possible mistake is

4% and total variance amounts to 13.87%. The total variance is explained to the greatest extent by the suprailiacal skin fold (ASISF), which has a positive effect on achieving better results in the test (P = 5.17%). The ABCS measure (bicristal span) also has a positive partial correlation with the criterion variable and it importantly explains the total variance (Q-BETA = .0444). It is necessary to mention the AWC (waist circumference) measure, too. It does not define the total variance with the criterion variable with an acceptable degree of certainty, but it indicates that it could, at least in extreme measures, exert negative effects on the results of the measurement.

The measure of the leg flexibility in the hip joint MFGH HSL (leg held sideways, side lying) shares 14.56% of its variance with the system of anthropometric variables. The relation significantly appears at the level of 2.8% of the possibility of mistake. Among individual predictors, only AUAC (upper arm circumference) defines with great certainty the total variance with leg held sideways in the side position and shows a positive partial correlation with the criterion variable. Other predictors do not have any significant effects on it (AUACM – maximal upper arm circumference, AWC – waist circumference).

A similar percent of the variance as in the measure of leg held sideways, side lying, is explained by the system of anthropometric variables also in the MFGH HFL measure (leg held forwards, back lying). Among individual predictors, the total variance is defined by thigh skin fold (ATSF) and knee diameter (AKD) with a high degree of certainty. Both show negative share in the criterion variable. The AUACR predictor (relaxed upper arm circumference) – Q-BETA = .0506 can be found slightly above a 5% limit of importance of contributions for explanation of total variance; nevertheless, this predictor is positive.

It can be asserted with utmost certainty that the system of anthropometric variables affects the variance of the measure MFGH FIS (leg held forwards inward, standing). The anthropometric variables explain as much as 17.73% of its variance resulting in a high degree of certainty when trying to establish the interrelations (Q = .0028). The greatest share in the measurement results in this test has ABM (body mass), which has a negative partial correlation with it. The calf circumference (ACC) is the second measure of the anthropometric variable system with an important share in explanation of total variance with great certainty (Q-BETA = .0161). Its effects on the result of the flexibility measure are positive.

## Discussion

The data show that the anthropometric variables have a more modest effect on the results of the angular flexibility measures than on the linear measures (Pistotnik, 1989).

Only in two flexibility measures of the shoulder girdle a significant relation to the system of body measures was found. Longitudinal measures of the skeleton have considerably less important effects on them than on the linear ones, although the sitting height (ASH) is still a dimension that helps explain their total variance. This can be explained by means of higher bending chances of the longer trunk which contributes to a greater stretching of the extremity, if compared to the initial position. The adaptation movements in the chest part of the spine are an important factor in the motions in the shoulder girdle with a maximal amplitude. Body mass in connection with elbow joint diameter (AED) is a negative factor in achieving better results, since the arms have to raise to the maximal amplitude of the motion in the direction opposite to the gravity force. This can lead us to the conclusion that the share of the segment's passive mass is negative in motor manifestations of flexibility, but the active muscular mass in the shoulder girdle has a prevailing share in the bigger amplitudes of the reached motion. Thigh circumference (ATC), which represents the mass of this body segment, facilitates strengthening of the lower part of the body with the help of a greater quantity and consequently an easier performance of the motor task with arms. Skin folds have various impacts on achieving greater amplitudes of the motions in the shoulder girdle. Based on a larger quantity of fatty tissue it can be inferred that the quantity of muscular tissue is smaller, which could inhibit the performance of the maximal motion amplitude. Fatty tissue offers less resistance when stretching; that is why it enables bigger amplitudes of motion even when the quantity is greater, provided that its layers do not physically inhibit the motion. Here, only the negative effect of the thigh skin fold (ATSF) is specific, which in some tests makes the subjects' initial placement difficult, thereby limiting the possibility of achieving better results (e.g. in MFGS BDP – arms held backward, downwards, prone).

At the same time, a part of the trunk flexibility measure variance can reliably be explained in two cases with the system of anthropometric variables. For longitudinal measures of the skeleton only selected effects on individual flexibility tests can be established whereas this is impossible for their general effect on them. Only the arm length (AAL) has negative effects on the flexibility measure variance and it is an indicator of a worse relative flexibility of people with longer skeleton measures. Generally, the total variance of the trunk flexibility measures and anthropometric variables is defined by subcutaneous fatty tissue which presents a physical barrier to the performance of a maximal flexion primarily in forward bends. In the case of circumferences only the chest circumference (ACHC) is important, because it contributes the active muscular mass to the performance of the trunk motions. The above-mentioned facts lead us to the conclusion that abdominal muscles develop the active force that is necessary for the maximal trunk flexion. Here it is important that other passive muscles do not offer a greater resistance. This most frequently takes place when the mass of the passive muscles is smaller and when it is replaced by subcutaneous fatty tissue. The negative connection between the bicristal span (ABCS) and the criterion variable can be explained with a greater quantity of non-active mass in the lower part of the abdomen and in the gluteal part, which most certainly negatively affects the motor manifestation of the test performance (Agrež, 1976).

The measures for establishing flexibility of the hip joint are linked to a great extent to the used system of anthropometric variables. Their total variance is determined to the greatest degree with body mass and skin folds. Normally, body mass and mass of the lower extremities represent primarily the excess weight that has to be overcome in order to achieve the maximal amplitude of the motion. The upper part of the trunk's mass measure gives a firm support for the performance of the motions with lower extremities. Consequently, people with greater trunk mass as well as upper arm mass perform motor tasks of this type more easily. On the basis of the data it can be asserted (similar findings were reported for the linear measures by Pistotnik, 1989) that active leg muscles and those of the abdominal part together with a firm support in the mass of the body's upper part contribute to better results. A wide pelvis offers a firm and wide support to the extensors in the hip joint, which enables the lower extremity to perform the maximal amplitude of the motion. The effects of the subcutaneous fatty tissue are shown in the same way as in other flexibility measures, depending on whether the tissue stretches or contracts in the flexion. It is believed that a greater quantity of thigh fatty tissue is primarily a mechanical hindrance to the performance of the maximal flexion in the hip joint.

From the above-mentioned facts it can be inferred that body measures do not significantly affect the results of the flexibility measurement with gravity goniometer. The length of body segments often acts as a negative factor on the angular measurement, since it is used for establishing the relative and not the absolute flexibility, as is the case with linear measures. Body mass always represents a negative factor, since this research was based primarily on motor tasks in relation to active flexibility. In these tasks it is also necessary to overcome the weight of the body segments and the passive resistance of the antagonist muscular groups, by means of one's own agonist muscular force. Only the active muscular mass that is best represented in the breadth of the chest is shown as a positive factor of flexibility. On the basis of greater quantities of fatty tissue a smaller muscular mass can be presupposed, which is important when stretching, since fatty tissue does not offer such a great resistance during stretching as does muscular tissue. In the flexion motions it inhibits the achievement of maximal amplitudes with its layers, since it comes between the moving body segments, thus reducing the size of the motion. Transverse measures of the skeleton indicate wide robust joints and are normally linked with the body mass and the mass of the extremities, therefore, their share in achieving great ranges of motion is negative.

To conclude, the regression analysis showed that morphological characteristics of male body generally appear in the majority of measures used for determining flexibility (see Tables 1-3). The sitting height is an important factor of the results' variance in some measures where the gravity goniometer was used. As regards other body measures, the circumferences and some skin folds figure in all of the flexibility measure procedures. The mass of body segments incorporated in the circumference can be either an active muscular mass which makes the performance of motion easier or a passive mass which makes the movement more difficult. Similarly, fatty tissue can inhibit motion because of its quantity. However, it can make stretching easier, if it replaces muscular tissue in the segment which stretches and consequently helps achieve greater ranges. Transverse measures of body segments are mainly connected with excess muscular mass and have a negative share in the measurement results, since in relation to the gravity force they make the performance of the majority of the selected motor tasks difficult.

On the basis of these findings, it can be concluded that the greatest flexibility would probably be attributed to a person of medium height, with a slightly longer trunk, greater chest circumference, slightly more graceful structure of the skeleton and a smaller quantity of the muscular mass. The distribution of fatty tissue, however, would be of genetic origin.

It is recommended that among the flexibility measures performed with the gravity goniometer the following measures can be used in a wider sports practice on the basis of the results obtained: three measures for shoulder girdle (arms held backwards, sideways, prone – MFGS BSP; arms held backwards, upwards, prone – MFGS BUP; and arms held upwards inward, sideways, standing – MFGS USS), three measures for trunk (arch, kneeling – MFGT ARK; trunk-bending to the right, standing – MFGT RBS; and trunk-bending forwards in forward split – MFGT BFS) and two hip joint measures (forward straddle – MFGH FS and leg held backward, standing – MFGH HBS). All the above-mentioned measures are easy to use, they yield reliable results (Pistotnik, 1991) and body morphological characteristics have a negligible share in them.

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