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# RELIABILITY AND DISCRIMINANT VALIDITY OF INSTRUMENTED SKATEBOARDING-SPECIFIC POSTURAL SWAY TEST: A PRELIMINARY STUDY

# ZANESLJIVOST IN DISKRIMINACIJSKA VELJAVNOST ŠPORTNO-SPECIFIČNEGA TESTA ZA ROLKARJE: PRELIMINARNA ŠTUDIJA.

## ABSTRACT

PURPOSE: The rise of skateboarding, particularly its inclusion in the Olympics, highlights the need for tailored balance assessment protocols, a notable gap in current research. In this study, we explored a new skateboarding-specific postural sway test. METHODS: 28 participants (15 skateboarders, 13 non-skateboarders) performed four balance tasks on a force plate. The tasks evaluated the Center of Pressure (CoP) movement in antero-posterior (AP) and medio-lateral (ML) directions, and CoP area. Reliability was measured using the intraclass correlation coefficient (ICC) for relative reliability, and the coefficient of variation (CV) for absolute reliability. RESULTS: Relative reliability was moderate to excellent (ICC: CoP AP velocity 0.75-0.89; CoP ML velocity 0.78-0.88; CoP Area 0.82-0.89). Absolute reliability was generally not acceptable, with CV exceeding 10% for almost all variables in all tasks. Significant task effects were observed in CoP velocity and area ($p < 0.001$), with a moderate group × task interaction in CoP area ($p = 0.024$; $\eta^2 = 0.12$), but no significant group differences. The third task (bipedal stance on a skateboard with eyes closed) nearly reached significance between groups ($t = 1.89$; $p = 0.069$). CONCLUSION: The study demonstrates good relative but limited absolute reliability and discriminant validity for the skateboard-specific sway test, questioning the usefulness of these tests and the specificity of balance adaptations in skateboarding.

*Keywords:* balance assessment, body sway, skateboarding, sports biomechanics, postural control.

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## IZVLEČEK

NAMEN: Porast rolkanja, še posebej njegova vključitev v olimpijske igre, kaže na potrebo po prilagojenih postopkih za ocenjevanje ravnotežja v tem športu. V tej raziskavi smo raziskali nov test odmikov od navpičnice med stojo, prilagojen za rolkarje. METODE: 28 udeležencev (15 rolkarjev, 13 ne-rolkarjev) je izvedlo štiri naloge ravnotežja na plošči za merjenje sil. Razčlenili smo gibanje središča pritiska (CoP) v smeri naprej-nazaj (NN) in levo-desno (LD), ter površino gibanja CoP. Zanesljivost je bila merjena z uporabo intraklasnega koeficienta korelacije (ICC) za relativno zanesljivost in koeficienta variacije (KV) za absolutno zanesljivost. REZULTATI: Relativna zanesljivost je bila zmerna do odlična (ICC: CoP AP hitrost 0,75-0,89; CoP ML hitrost 0,78-0,88; CoP površina 0,82-0,89). Absolutna zanesljivost na splošno ni bila sprejemljiva, saj je KV presegel 10% za skoraj vse spremenljivke v vseh nalogah. Opazili so pomembne učinke naloge na hitrost in površino CoP ($p < 0,001$), z zmerno interakcijo skupine × naloge samo za površino CoP ($p = 0,024$; $\eta^2 = 0,12$), vendar brez pomembnih razlik med skupinami. Za tretjo nalogo (sonožna stoja na rolki z zaprtimi očmi) je analiza skoraj dosegla statistično pomembnost razlik med skupinami ($t = 1,89$; $p = 0,069$). ZAKLJUČEK: Študija prikazuje dobro relativno, vendar omejeno absolutno zanesljivost in diskriminacijsko veljavnost za prilagojen test ravnotežja za rolkarje, kar postavlja pod vprašaj uporabnost testa ter specifičnosti prilagoditev ravnotežja pri tej populaciji.

*Ključne besede:* ocena ravnotežja, telesno nihanje, rolkanje, športna biomehanika, nadzor drže.

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## INTRODUCTION

In 2003, skateboarding in the USA was practiced by over 11 million people, a figure comparable to those of tennis, volleyball, and soccer. Since 2017, this sport has gained recognition as an Olympic discipline (Batuev & Robinson, 2017), reflecting its growing popularity and interest on a global level. For example, in Colombia, skateboarding is endorsed by the Colombian Skateboarding Federation, with 134 athletes engaged at the national level, with the number of amateur participants being even higher (Castillo-Daza et al., 2021). Skateboarding subjects the body to asymmetrical loads, involving horizontal speed generation through the rear leg's push-off while the front leg bears the skateboarder's weight. This practice may lead to uneven adaptation in the limbs over time. Besides propulsion, the fundamental maneuver in skateboarding is the 'ollie' (Frederick et al., 2006), a movement similar to the countermovement jump (CMJ). This jump enables skaters to leap over, onto, and off various objects, and to execute additional tricks. As the sport's prominence and the complexity of maneuvers have increased, so have the skill requirements for skateboarders. Advanced techniques frequently require foot positions that increase the risk of both acute and chronic ankle injuries. This risk is further increased due to the nature of the sport, involving high speeds and high metabolic demands (Furr et al., 2021).

Skateboarding lacks evidence-based training or safety guidelines, despite leading to 77,476 hospitalizations in 2017, as reported by NEISS. Upper extremity injuries are most common (55–63%), followed by lower extremity (17–26%), and thoracoabdominal and spine injuries (1.5–2.9%) (Shuman & Meyers, 2015). Despite the high incidence of injuries and the large and growing number of participants in this sport, skateboarding is underrepresented in the scientific and clinical literature, including the aspect of balance and postural control (Castillo-Daza et al., 2021; Frederick et al., 2006; Ou et al., 2021). Postural balance is not only an important prerequisite for performing everyday tasks and avoiding falls, but also for the successful performance of specific skills in a sporting population (Boccolini et al., 2013; Hrysomallis, 2011). In addition to associations with performance measures, balance performance appears to be related to injury risk in athletes (Hrysomallis, 2007). In a review of the literature, balance deficits were found to be associated with an increased risk of injury, including ankle sprains and muscle, tendon and ligament injuries in athletes from a variety of sports (Brachman et al., 2017). A deficit in dynamic balance has been shown to be a risk factor for injuries, particularly in the lower limbs, such as muscle/ tendon strains and ligament sprains (De Noronha et al., 2013; Grassi et al., 2018). Although skateboarders were reported to accept injuries as a common attribute of their sport (Haines et al., 2010), they might benefit from better methods for assessment and improvement of balance.

Studies have demonstrated that movement technique and equipment play a significant role in attenuating high-impact experienced during skateboarding maneuvers (Determan et al., 2009, 2010). Additionally, as previously discussed, proficient balance may also provide a protective effect against injuries. For instance, high variations in postural sway during the one-leg standing test may partly account for the increased prevalence of ankle injuries in basketball players and could serve as a screening tool prior to the basketball season (Wang et al., 2006). Skateboarding athletes have been shown to exhibit good balance during tests with eyes open and eyes closed (Castillo-Daza et al., 2021). Ou et al. (Ou et al., 2021) studied professional and amateur skateboarders and revealed that long-term skateboarding training improves balance, which is particularly evident in more demanding balance tests. Wong and Brown (Wong & Brown, 2015) conducted a comparison of balance abilities between skateboarders and non-skateboarders, suggesting that the dynamic nature of skateboarding could enhance participants' stability or comfort in uneven stances. Their study primarily revealed the impact of right leg dominance on balance performance. Additionally, they observed that individuals tend to lean more on their dominant (usually right) leg and backward in a 'regular' stance, where the left leg is positioned in front. In a separate study, the balance of the supporting leg and the pushing leg was compared (Patton et al., 2015). They found that skateboarders maintain stability on an unstable surface equally well with both legs. Complementing these findings, Tovar et al. (Tovar et al., 2013) determined that long-term skateboarding for transport does not affect the rate of center of gravity oscillation during single-leg standing. In summary, these studies suggest the importance of assessments and testing in identifying potential injury risks and guiding targeted training strategies to enhance skateboarding performance. Considering the various sensory systems involved in maintaining balance (Maurer et al., 2006) and the distinct results under different testing conditions (such as with eyes open versus closed) (Johansson et al., 2017; Okuda et al., 2005), it could be important to conduct evaluations under diverse conditions to effectively address sports injury prevention and rehabilitation in skateboarding.

In this preliminary study, we begin to address the critical need for specific and reliable assessment tools in skateboarding. While the existing literature provides insights into the balance abilities and injury risks associated with skateboarding, there is a lack of standardized, skateboarding-specific balance testing protocols. This gap in the research limits our ability to fully understand and mitigate the unique biomechanical demands and injury risks. Our focus is on assessing static postural balance through both conventional and novel skateboarding-specific postural tasks. The specific objective of this study is to preliminarily test the reliability and discriminant validity of these newly developed skateboarding-specific postural sway tests. By introducing and validating these skateboarding-specific postural sway tests, we aim to lay the groundwork for more comprehensive research in this field, eventually leading to enhanced safety and performance guidelines for skateboarders.

## METHODS

### Participants

The study involved a convenience sample of 28 individuals (4 women), of which 15 were skateboarders (2 women), and 13 were non-skateboarders (2 women), having never engaged in skateboarding. Exclusion criteria included less than one year of skateboarding experience (for the skateboarder group), age under 10 or over 45 years, musculoskeletal injuries of the lower limb within the last 6 months, pregnancy, neuromuscular disorders, as well as any vestibular diseases or inner ear injuries in the past 6 months. Participants completed a demographics questionnaire and provided written consent to participate in the study. For minors, consent was obtained from their parents or legal guardians. The research procedures complied with the ethical approval granted by the Medical Ethics Committee of the [blinded for review].

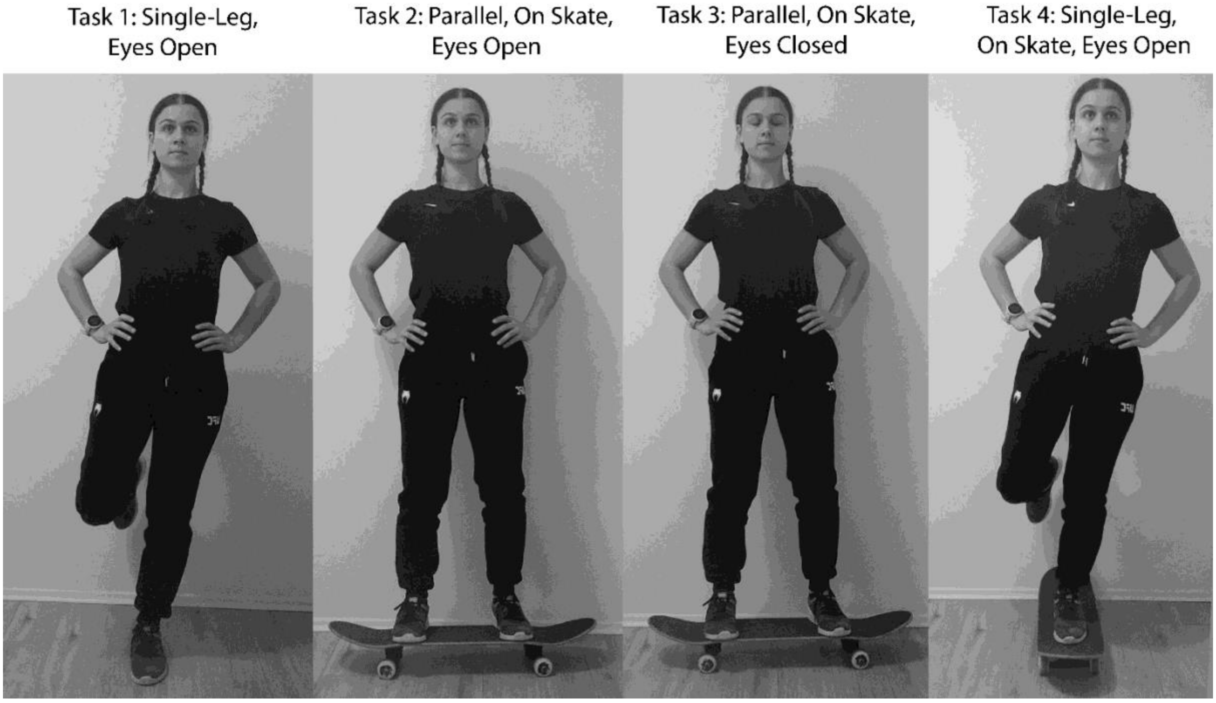
### Study design and tasks

The study was designed as a combination of cross-sectional comparative experiment (to determine the discriminant validity of the tests) and repeated-measures experiment (to determine test-retest reliability). Participants were required to arrive to the laboratory well-rested, having not consumed alcohol within the last 24 hours or coffee and similar stimulants withing the last 12 hours. They were asked to bring comfortable clothes and sports shoes. Balance was assessed in four different tasks performed consecutively, each consisting of three 30-second repetitions with 60-second rest intervals. The tasks performed by participants (Figure 1) were as follows:

- Task 1: Single-leg stance on a flat surface with eyes open (dominant leg; for skateboarders, the front leg during skateboarding)
- Task 2: Bipedal stance on a skateboard with eyes open
- Task 3: Bipedal stance on a skateboard with eyes closed

- Task 4: Single-leg stance on a skateboard with eyes open (dominant leg; for skateboarders, the front leg during skateboarding)

Figure 1. Postural tasks used in the study. Shown without force plate on purpose for greater clarity.




For each task, one 30-s familiarization trial was done. If balance was lost during the main trials, the measurement was repeated. During the 1st, 2nd, and 4th tasks, participants were instructed to focus on a 1 $cm^2$ black dot at eye level on a white background, 2 meters from the force plate. For skateboard tests (using the same skateboard for all measurements), the skateboard was placed directly on the force plate. After 7-10 days, participants repeated the measurements at the same time of day. They were advised to avoid intense training and maintain their usual diet for two days before each session.

In the balance assessment tasks involving a skateboard, we utilized a standardized skateboard to ensure uniformity across all measurements. The skateboard was specifically chosen for its dimensions and features to accommodate to a wide range of participant sizes while providing a consistent testing environment. The deck of the skateboard, made of 7-ply maple, had a width 20.5 cm and a length of 81 cm, with a medium concave and a double kicktail, and the wheelbase measuring 14.375 inches (36.5 cm). The skateboard featured wheels with a diameter of 54 mm, balancing stability and maneuverability, which are crucial for tasks requiring precise balance control.

### Measurements and outcome measures

Data were collected using a Kistler force plate (model 9260AA6; Winterthur, Switzerland; sampling frequency: 1000 Hz) and the MARS software (Measurement, Analysis, and Reporting Software; S2P, Ljubljana, Slovenia). This software enabled the acquisition of standard measures of static balance based on center of pressure (CoP) movement. We chose to limit the analysis to three common variables to avoid inflating Type 1 statistical error. In particular, CoP velocity in antero-posterior (AP) and medio-lateral (ML) directions, as well as CoP area, were calculated. CoP velocity was determined as the common length of the trajectory of the CoP sway in the respective direction divided by the measurement time. CoP area was defined as the total area swayed by the CoP trajectory with respect to the central stance point. A questionnaire was used to gather demographic data, information on the dominant leg, any injuries sustained in the past 12 months, engagement in sports activities, and for skateboarders, additional details about their skateboarding duration, weekly frequency of skateboarding sessions, and stance on the skateboard.

### Statistical analysis

Data were analyzed using SPSS software (version 25.0, IBM, Armonk, NY, USA). Descriptive statistics are presented as means and standard deviations. Test-retest reliability was analyzed using the intraclass correlation coefficient (ICC; absolute agreement) for relative reliability, typical error for absolute reliability, and paired t-tests for systematic error. ICC was interpreted as following: > 0.9 (excellent), 0.9–0.75 (good), 0.75– 0.50 (moderate), and < 0.5 (poor) (Koo & Li, 2016). Typical error was divided by the mean value to obtain the coefficient of variation, which was interpreted as unacceptable reliability (CV >10%), moderate reliability (CV = 5–10%), or good reliability (CV <5%) (Banyard et al., 2017). The main analysis was conducted using a two-way mixed Analysis of Variance (ANOVA), where one factor was the group (skateboarders, control group) and the other was the task (four tasks). Additional comparisons were made using post-hoc Bonferroni corrected t-tests, and one-way ANOVAs and t-tests within individual groups or tasks. Statistical significance was accepted at $\alpha < 0.05$.

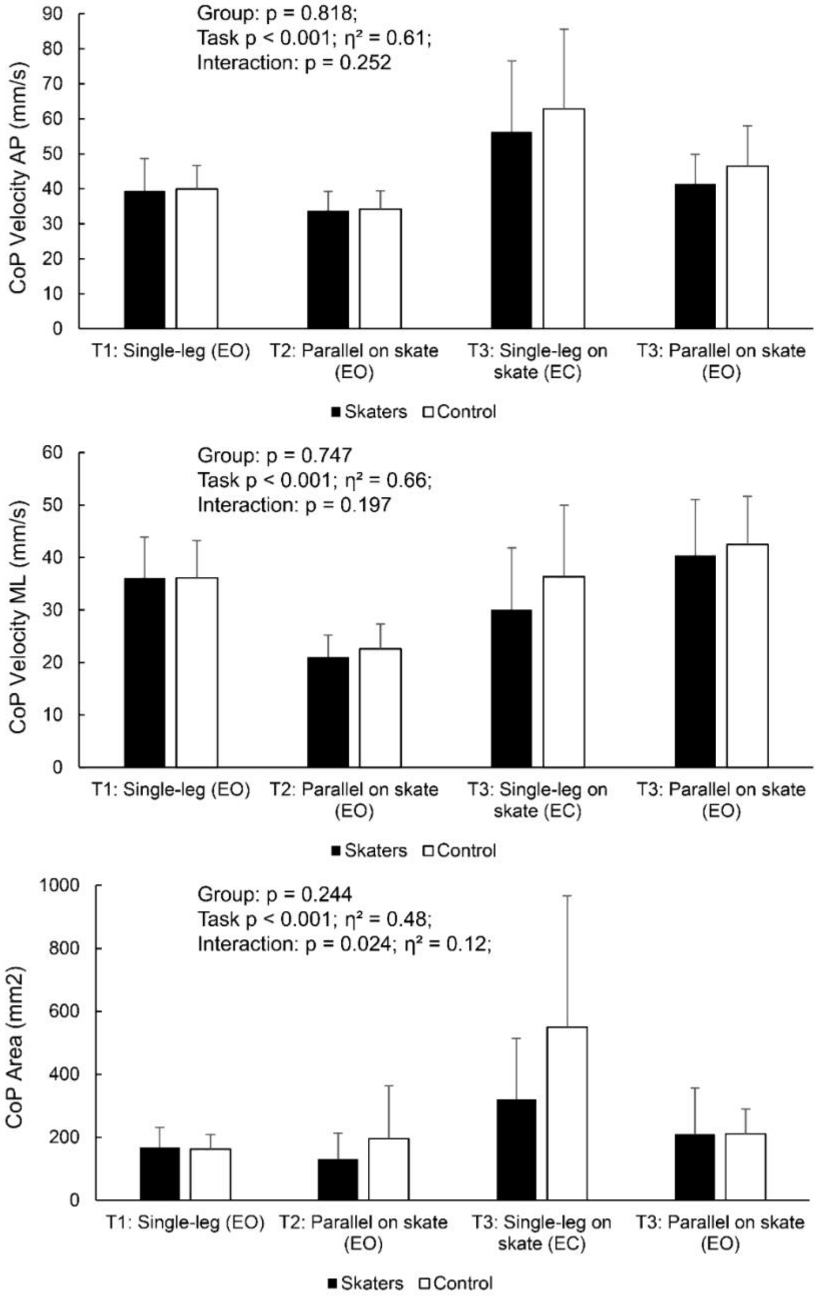
## RESULTS

The skateboarder group consisted of 15 individuals (2 females, 13 males), averaging 30 years in age (SD = 7.5; range = 11-41 years), with a mean height of 177.9 cm (SD = 9.7) and weight of 72 kg (SD = 13.4). The control group included 13 individuals (2 females, 11 males), also averaging 30 years in age (SD = 4.9; range = 24-38 years), with an average height of 178.9 cm (SD = 8.5) and weight of 78.9 kg (SD = 15.1). The average duration of skateboarding experience was 15 years (min = 1 year, max = 30 years), with an average frequency of skateboarding three times per week (min = 2, max = 6). Two skateboarders participated in competitions, while the remaining 13 did not. Seven skateboarders engaged in other sports, including cycling (n = 3), running (n = 1), roller skating (n = 1), soccer (n = 1), home workouts (n = 1), and slacklining (n = 1). In the control group, 11 individuals were involved in sports activities such as fitness (n = 8), running (n = 1), soccer (n = 2), French boxing (n = 1), yoga (n = 1), and climbing (n = 1). In the skateboarder group, five individuals reported lower limb injuries in the past 12 months, including mild ankle sprains (n = 3), knee ligament strain (n = 1), a fractured bone in the foot (n = 1), and Achilles tendinopathy (n = 1). All skateboarders successfully completed the tasks without difficulty. In contrast, some participants in the control group were unable to perform Task 4 (single-leg stance on a skateboard; n = 2), or experienced significant challenges (visible movement and translation of the skateboard), particularly with Tasks 3 and 4. Moreover, most individuals in the control group required assistance to mount and dismount the skateboard, while skateboarders were able to do so independently.

**Differences between skateboarders and the control group**

The analysis indicated a large and statistically significant effect of the task on CoP velocity in both AP and ML directions ($p < 0.001$; $\eta^2 = 0.61$ and 0.66, respectively), without significant group effects ($p = 0.818$ and 0.747, respectively) or group-task interactions ($p = 0.252$ and 0.197, respectively). Regarding CoP Area, we observed a substantial and statistically significant effect of the task ($p < 0.001$; $\eta^2 = 0.48$) as well as a moderate and significant group-task interaction ($p = 0.024$; $\eta^2 = 0.12$), but no significant effect was found for the group alone ($p = 0.244$). Separate ANOVA for each group showed a significant task effect on CoP Area ($p < 0.001$), with a slightly lower effect among skateboarders ($\eta^2 = 0.43$) compared to the control group ($\eta^2 = 0.51$). Independent sample t-tests indicated no differences between groups for the first ($t = 0.196$; $p = 0.846$), second ($t = 1.31$; $p = 0.199$), and last task ($t = 0.004$; $p = 0.997$). The third task (bipedal stance on a skateboard with eyes closed) approached statistical significance between groups ($t = 1.89$; $p = 0.069$), with a moderate to high effect size ($d = 0.75$). The results are also displayed in Figure 2.

Figure 2. Differences between skateboarders and control group across tasks.




## Reliability

Table 1 contains the reliability statistics. Relative reliability was moderate to excellent across all tasks and variables, with point estimates of ICC indicating good reliability for CoP AP velocity (ICC = 0.75-0.89), CoP ML velocity (ICC = 0.78-0.88) and CoP Area (ICC = 0.82-0.89). For absolute reliability, the upper limit of CV crossed the 10 % margin for all tasks. Point estimates indicated acceptable absolute reliability of CoP AP and ML velocity for Tasks 1, 2 and 4 (CV = 5.69 – 7.61 %), but not for Task 3 (CV = 10.18 and 11.99 %). CoP area exhibited unacceptable absolute reliability in all four tasks (CV = 14.12 – 33.44 %).

Table 1: Reliability statistics.

| Variable | Task | Session 1 | | Session 2 | | Relative reliability | | | Absolute reliability | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | ICC | 95 % CI | | CV | 95 % CI | |
| CoP Velocity - AP (mm/s) | 1 | 39.68 | 7.98 | 38.86 | 6.72 | 0.80 | 0.59 | 0.91 | 8.66 | 6.70 | 12.26 |
| | 2 | 33.99 | 5.27 | 33.76 | 5.41 | 0.75 | 0.51 | 0.88 | 8.15 | 6.31 | 11.54 |
| | 3 | 59.32 | 21.27 | 58.74 | 17.08 | 0.79 | 0.57 | 0.90 | 15.50 | 11.99 | 21.94 |
| | 4 | 43.56 | 9.97 | 40.99 | 8.04 | 0.89 | 0.76 | 0.95 | 7.40 | 5.69 | 10.57 |
| CoP Velocity - ML (mm/s) | 1 | 36.09 | 7.37 | 36.32 | 7.27 | 0.78 | 0.55 | 0.89 | 9.84 | 7.61 | 13.92 |
| | 2 | 21.78 | 4.39 | 21.55 | 5.28 | 0.82 | 0.62 | 0.91 | 9.72 | 7.52 | 13.76 |
| | 3 | 32.97 | 12.83 | 30.78 | 10.40 | 0.88 | 0.74 | 0.94 | 13.17 | 10.18 | 18.64 |
| | 4 | 41.27 | 9.91 | 39.91 | 8.40 | 0.83 | 0.64 | 0.92 | 9.63 | 7.41 | 13.77 |
| CoP area ($mm^2$) | 1 | 160.9 | 50.8 | 165.5 | 53.6 | 0.82 | 0.61 | 0.91 | 14.12 | 10.87 | 20.18 |
| | 2 | 151.9 | 129.3 | 115.3 | 71.1 | 0.89 | 0.75 | 0.95 | 27.73 | 21.22 | 40.05 |
| | 3 | 414.5 | 323.1 | 332.9 | 283.1 | 0.84 | 0.65 | 0.93 | 33.44 | 25.59 | 48.29 |
| | 4 | 181.8 | 59.6 | 165.7 | 72.4 | 0.64 | 0.27 | 0.84 | 23.19 | 17.52 | 34.29 |

CoP – centre of pressure; AP – antero-posterior; ML – medio-lateral; SD – standard deviation; CI – confidence interval; CV – coefficient of variation.

## DISCUSSION

The primary objective of this research was to ascertain balance differences between skateboarders and non-skateboarders. Observational differences were noted during measurements; skateboarders generally maintained balance on a force plate without assistance, unlike control group participants. Statistical analysis revealed significant task effects for all variables, with a moderate interaction between group and task for CoP area, and no group effect. Skateboarders exhibited slightly smaller increases in CoP area on the skateboard compared to the control group. However, no significant group differences were observed in most tasks, suggesting comparable balance in both groups under various conditions. High participant variability within groups was noted, indicating the need for further research with larger samples.

Literature indicates skateboarding's high balance requirements. Castillo-Daza et al. (Castillo-Daza et al., 2021) highlighted skateboarders' stability, especially in tests with eyes closed, attributing it to sports adaptation for fall prevention and dynamics development. Ou et al. (Ou et al., 2021) noted better balance in professional skateboarders compared to amateurs, with significant improvements in prolonged skateboarding training, particularly in challenging balance tests. Their study also found that skateboarders without old injuries had better stability.

In contrast, our study's participants, being recreational or amateur skateboarders, showed smaller differences from the control group. One study (Wong & Brown, 2015) observed greater average medio-lateral (ML) deviation in skateboarders, suggesting their comfort in uneven positions, a finding not replicated in our study. Also, like Tovar et al. (Tovar et al., 2013) we found no significant differences in CoP movement during single-leg stance between the two groups, explained by skateboarders' prolonged time in tandem stance. One explanation for the lack of significant differences in our study might be that balance adaptations are highly specific. Balance is multidimensional and task-specific, leading to limited transfer of adaptations from trained to untrained tasks and other motor activities (Bakker et al., 2021; Kümmel et al., 2016). We anticipated that adding a skateboard to the test would highlight differences between groups due to this specificity. However, our measurements were static (standing still), while skateboarders require balance under more dynamic conditions. Several skateboarders mentioned during measurements that they are accustomed to standing and performing tricks on a moving skateboard (dynamically) rather than statically. Some participants also complained about the size of the skateboard used and the unfamiliarity with a skateboard other than their own.

One interesting observation from this study is that the only distinction between the groups emerged during task performed with eyes closed. This outcome might imply that skateboarders possess superior proprioception, a sensory skill that becomes particularly evident in conditions where visual cues are absent (Maurer et al., 2006; Peterka, 2002). Consequently, this finding opens the door for future research to further investigate the tests conducted under eyes-closed conditions. The need for such focused investigations is further supported by the fact that different testing conditions can lead to varied results in different scenarios. For example, one study highlighted notable deficiencies in postural sway linked to anterior cruciate ligament injuries when participants were tested with their eyes closed, whereas these deficits were not apparent in conditions where their eyes remained open (Okuda et al., 2005). This reflects the complex interplay between sensory input and motor control, emphasizing the need for a broad spectrum of testing conditions, especially in the context of injury prevention and rehabilitation.

The results demonstrated good relative reliability in all tasks, while absolute reliability was mostly not acceptable. No specific literature on balance test repeatability and reliability for skateboarders was found, allowing only comparisons with similar research in other fields or sports. Quatman-Yates et al. (Quatman-Yates et al., 2013) demonstrated good test-retest reliability for young athletes’ postural sway measurement, without evidence of learning effects.

It has been suggested that averaging multiple measurements could improve reliability in postural sway assessments (Golriz et al., 2012). Our reliability scores might have also benefitted from more measurement averages.

To potentially enhance balance and mitigate injury risks, it may be beneficial for skateboarders to experiment with dynamic balance exercises as part of their routine. Suggested activities include proprioceptive training, such as single-leg stands and tandem walking, in addition to using balance boards and engaging in sport-specific exercises on the skateboard. Engaging in these activities, especially under conditions that limit visual input (e.g., with eyes closed), could offer improvements in dynamic balance pertinent to skateboarding. Although further research is needed to confirm this, we believe that regular incorporation of these exercises, progressively increasing in difficulty, might assist skateboarders in better adapting to the sport's demands, thereby potentially contributing to more effective injury prevention strategies.

The study's limitations include a predominantly male participant pool, making the results less applicable to females. The small sample size limits the certainty of the results and their repeatability. The inclusion of mainly recreational skateboarders could have influenced the minimal differences observed. Ou et al. (Ou et al., 2021) found that professional skateboarders have higher stability scores than amateurs, suggesting future research should include more professionals for clearer insights. A higher incidence of lower limb injuries, primarily ankle sprains, in skateboarders than in the control group (5 vs. 1) might have impacted their performance. Nearly all control group members were regularly physically active, possibly contributing to the similar results between groups. Some control group participants expressed fear of standing on a skateboard, especially with eyes closed or on one leg, which might have further influenced the results. Finally, the use of only a single 30-second familiarization trial may have been insufficient for effective familiarization with atypical postural control tasks.

## CONCLUSION

In conclusion, this study revealed that the skateboard-specific postural sway test exhibits good relative reliability but limited absolute reliability and discriminant validity. The absence of significant balance differences between skateboarders and non-skateboarders, particularly in skateboard-specific tasks, challenges the assumption of unique balance adaptations in skateboarding. These findings emphasize the need for more refined and comprehensive balance assessment protocols in skateboarding, accounting for the sport's specific biomechanical demands. Future research should focus on larger and more varied participant groups to enhance the generalizability and applicability of balance testing in skateboarding.

### 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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