# Correlation Analysis of Postural Balance in Roller Skate Athletes Between Single Leg Stand and Tandem Stand

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## Article's Info

## Abstract

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**Introduction:** Postural balance is a crucial component in the performance of roller skate athletes, especially in maintaining stability during dynamic movements. **Objectives:** This study aimed to analyze the relationship between two postural balance assessment methods: single leg stands and tandem stands, among roller skate athletes aged 10 to 15 years. **Method:** The study involved 15 athletes selected purposively. Balance data were collected using the single-leg stand and tandem stand tests and analyzed with the Shapiro-Wilk normality test and Pearson correlation test. **Result:** The results showed that both variables were normally distributed and had a very strong and significant correlation ($r = 0.934$; $p < 0.001$). These findings indicate that better balance performance in one method tends to reflect better performance in the other. This confirms that both methods can represent the postural balance ability of roller skate athletes. **Conclusion:** The study concludes that there is a very strong positive correlation between single leg stand and tandem stand, which can serve as a basis for evaluating and developing balance training programs for roller skate athletes.

**INTRODUCTION**

Postural balance refers to an individual's ability to maintain their body's center of mass within predetermined stability limits, both in static and dynamic conditions (Pope, M., Johnson, T., & Smith, R., 2022). In roller skating, especially at the competitive level, postural balance is crucial for supporting an athlete's performance when executing high-speed maneuvers in dynamic situations. Impaired balance can lead to reduced performance and an increased risk of injury, particularly in adolescents who are still undergoing neuromuscular development (Paillard, 2019; Vuillerme & Boisgontier, 2021). Given the high risk of falls and injuries inherent in this sport, and the growing number of young athletes involved, there is an urgent need to examine postural balance comprehensively to ensure safety, enhance performance, and support long-term athlete development.

Previous studies have shown that postural balance is influenced by several factors, including strength training, dual-task training, age, gender, and level of sports expertise (Ghai et al., 2017; Behm et al., 2015; Saevarsson & Nordahl, 2022). In the context of balance assessment, several tests have been widely used, such as the **Single Leg Stand (SLS)** and the **Tandem Stand (TS)**, due to their simplicity, cost-effectiveness, and reliability in measuring static postural stability (Lencioni et al., 2019; Mancini & Horak, 2016).

Although SLS and TS have been extensively applied in general and elderly populations to assess fall risk (Kim & Park, 2020), as well as in rehabilitation and fitness contexts (Gaerlan et al., 2019), research that specifically compares the relationship between the two in adolescent roller-skating athletes remains limited. Understanding the correlation between these assessment methods is essential to streamline the evaluation process and to design targeted training programs.

This study seeks to fill that gap by analyzing the relationship between two postural balance assessment methods—Single Leg Stand and Tandem Stand—among roller skate athletes aged 11 to 15 years. The novelty of this research lies in its focus on a young athletic population engaged in a sport that demands a high level of balance, and its correlational approach to determine whether one method can predict the performance of the other.

The objective of this article is to determine whether there is a significant and strong relationship between the Single Leg Stand and the Tandem Stand in assessing postural balance in roller skate athletes. The findings are expected to contribute to selecting efficient assessment methods and to serve as a reference in designing balance training programs tailored to the characteristics and needs of young athletes.

**METHOD**

This study employed a quantitative approach with a correlational design to analyze the relationship between two postural balance assessment methods: the Single Leg Stand (SLS) and the Tandem Stand (TS). The research was conducted on October 5, 2024, at the

Physiotherapy Laboratory, located on the first floor of the GKB 2 Building, Universitas Muhammadiyah Sidoarjo.

The study subjects consisted of 15 female roller skate athletes in Sidoarjo, aged between 11 and 15 years. Participants were selected using purposive sampling, with the following inclusion criteria: (1) actively training at least three times per week, (2) no history of lower limb injuries within the past three months, and (3) willingness to participate in all research procedures.

The exclusion criteria included: (1) medically diagnosed neurological disorders or balance impairments, (2) currently undergoing physical rehabilitation or using mobility aids, and (3) failure to complete all data collection stages or refusal to participate during the measurement process.

Data collection was conducted through two types of static balance assessments: 1) Single Leg Stand (SLS): measured the duration (in seconds) the athlete could stand on one leg without losing balance. Tandem Stand (TS): measure2) d the duration (in seconds) the athlete could maintain a heel-to-toe position without losing balance.

All measurements were performed using the HumanTrack Vald System, a high-accuracy digital evaluation device. Each participant completed three trials for each test, and the mean value was used as the final data point. All assessments were conducted barefoot and with the gaze directed forward to control for visual influence.

Data were analyzed using the Shapiro-Wilk normality test to determine the data distribution, and the Pearson correlation test to assess the strength and direction of the relationship between the two variables. All analyses were conducted using standard statistical software.

This study was approved by the Health Research Ethics Committee, Faculty of Medicine, Universitas Airlangga, under Ethical Clearance No. 145/EC/KEPK/FKUA/2024.

**RESULT AND DISCUSSION**

Postural balance evaluation data were obtained through measurements using the Single Leg Stand (SLS) and Tandem Stand (TS) tests on 15 roller skate athletes aged 10–15 years. The Shapiro-Wilk normality test showed that both variables were normally distributed ($p > 0.05$), allowing further analysis using the Pearson correlation test.

The average balance duration in the Single Leg Stand (SLS) test was 26.4 seconds with a standard deviation of ±5.1 seconds, while in the Tandem Stand (TS) test, the average was 27.1 seconds with a standard deviation of ±4.8 seconds. Pearson correlation analysis showed a very strong and significant relationship between SLS and TS, with a correlation coefficient of $r = 0.934$ and a significance level of $p < 0.001$.

These findings indicate that better postural balance performance in one method tends to be associated with better performance in the other. Therefore, both methods can reliably represent the postural balance ability of adolescent roller skate athletes.

This study was conducted on 15 roller skate athletes who are members of the Faster Club Sidoarjo. Table 1 presents the general characteristics of the respondents who participated as subjects in this research.

Table 1. Respondent Characteristics

| Category | Frequency | Percentage (%) |
|---|---|---|
| Age (Years) | | |
| 11 years | 2 | 13.3 |
| 12 years | 5 | 33.3 |
| 13 years | 2 | 13.3 |
| 14 years | 5 | 33.3 |
| 15 years | 1 | 6.7 |
| Total | 15 | 100.0 |
| BMI Category | | |
| Underweight | 3 | 26.7 |
| Normal | 10 | 66.7 |
| Overweight | 2 | 6.7 |
| Total | 15 | 100.0 |

Source: Primary data 2025

**Statistical Test Results**

An initial analysis was conducted using the Shapiro-Wilk test to determine whether the data for both variables followed a normal distribution. The test results are presented in Table 2.

Table 2. Shapiro-Wilk Normality Test Results

| Variable | W Statistic | W p-value | Distribution |
|---|---|---|---|
| Single Leg Stand | 0,962 | 0,645 | Normal (p > 0,05) |
| Tandem Stand | 0,974 | 0,789 | Normal (p >0,05) |

Note: Data are considered normally distributed if p > 0.05.

Since the p-values for both variables are greater than 0.05, it can be concluded that the data are normally distributed. Therefore, the Pearson correlation test was selected as the appropriate method to analyze the relationship between the two variables.

Table 3. Pearson Correlation Test Results between Single Leg Stand and Tandem Stand

| Variable 1 | Variable 2 | Correlation Coefficient (r) | p-value | Interpretation |
|---|---|---|---|---|
| Single Leg Stand | Tandem Stand | 0,934 | $3,45 \times 10^{-7}$ | Very strong and significant |

Note: Correlation strength interpretation: 0.00–0.19 = very weak, 0.20–0.39 = weak, 0.40–0.59 = moderate, 0.60–0.79 = strong, 0.80–1.00 = very strong.

These results indicate a very strong and statistically significant relationship between balance performance on the Single Leg Stand and the Tandem Stand. The correlation coefficient of 0.934 falls within the very strong category (r ≥ 0.90), suggesting that high performance in one test is very likely to be accompanied by high performance in the other.

## DISCUSSION

### Respondent Characteristics Based on Age

The majority of roller skate athletes in this study were aged 12 and 14 years (each n=5; 33.3%), followed by those aged 11 and 13 years (each n=2; 13.3%), and one participant aged 15 years (6.7%). This age distribution reflects the early to mid-adolescent period, which is a critical window for neuromotor development, particularly in relation to postural control and balance (Clark et al., 2020). During adolescence, the neuromuscular system is still undergoing maturation, making individuals more responsive to motor learning and balance training stimuli (López-Valenciano et al., 2016; Paillard, 2019).

Therefore, evaluating postural balance during this phase is not only relevant for identifying current motor abilities but also serves as an early screening method for potential developmental delays or imbalances that may affect athletic performance and injury risk. The predominance of participants in this sensitive developmental stage supports the relevance of this study in the context of youth athletic development.

Although the study focused only on female athletes, this subgroup provides valuable insight into balance capabilities in adolescent females, a group that may exhibit different biomechanical and neuromuscular characteristics compared to their male counterparts (Nagano et al., 2020). Future research should aim to include male participants to enhance the generalizability of the findings.

### Respondent Characteristics Based on BMI Status

Based on BMI classification, 66.7% of participants were in the normal category, while 26.7% were underweight and 6.7% were overweight. BMI is a widely recognized factor that can influence postural control. Normal BMI is typically associated with optimal muscle mass and weight distribution, supporting more stable postural control (Behm et al., 2015). In contrast, being underweight may reflect reduced muscle strength, which can compromise stability (Saevarsson & Nordahl, 2022), while being overweight may increase the difficulty of balance

maintenance due to higher biomechanical load and shifted center of mass (Vuillerme & Boisgontier, 2021).

While this study did not investigate BMI effects in-depth, this variable adds important context to understanding interindividual variability in balance performance. Future studies may explore these relationships more thoroughly using stratified analysis based on BMI categories.

**Correlation Between Single Leg Stand and Tandem Stand**

The Pearson correlation coefficient between the SLS and TS was $r = 0.934$ ($p < 0.001$), indicating a very strong positive linear relationship. This implies that participants who performed well in one test were very likely to perform well in the other. The result supports the hypothesis that both tests evaluate similar aspects of static postural control, likely involving shared neuromuscular mechanisms such as proprioception, vestibular input, and motor coordination (Lencioni et al., 2019; Ghai et al., 2017).

This strong correlation strengthens the argument for the interchangeable or complementary use of both tests in practice. Coaches, physiotherapists, or medical teams can choose either method based on context—such as space availability, equipment constraints, or athlete preference—without significantly compromising the validity of the assessment.

Moreover, this finding aligns with the theory that static balance can be reliably measured using different body postures, as long as key principles such as load symmetry and center of mass alignment are respected (Mancini & Horak, 2016). It also demonstrates the ecological validity of simple, low-cost clinical tools such as SLS and TS for use in field settings.

**Implications of the Study**

The implications of this study are both practical and theoretical. Practically, the demonstrated high correlation between SLS and TS offers flexibility in postural assessment protocols. Institutions or clubs with limited resources can confidently use either test to assess balance in young roller skate athletes. Theoretically, the study contributes to the literature by confirming the cross-method consistency of static balance assessments in a specific athletic population.

Furthermore, these findings may serve as a basis for the development of targeted balance training interventions. Given the role of balance in injury prevention and performance optimization in roller skating, using either SLS or TS to monitor progress can help tailor neuromuscular training protocols. Incorporating balance evaluations into routine athlete assessments may enhance early detection of deficits and inform individualized programming (Behm et al., 2015; Saevarsson & Nordahl, 2022).

**Limitations and Future Directions**

Despite its strengths, this study has limitations. The small sample size and restriction to female participants limit generalizability. Additionally, only static balance was assessed, while dynamic balance, which is highly relevant in roller skating, was not evaluated. Future research should include larger, more diverse samples and incorporate dynamic balance measures (e.g., Y-Balance Test or Balance Error Scoring System) to provide a more comprehensive understanding of athletes' postural control. Including variables such as training history, competition level, and proprioceptive capacity could also enrich the findings.

**CONCLUSION**

This study found a very strong and significant correlation between the Single Leg Stand and Tandem Stand in assessing postural balance among roller skate athletes aged 11–15 years. These results suggest that both tests can be used complementarily or interchangeably as effective tools in evaluating static balance, particularly in sports requiring high stability like roller skating.

Coaches and practitioners may select either or both tests for efficient performance assessments. Future studies are recommended to involve larger and more diverse samples, and consider additional variables such as gender, athletic experience, and dynamic balance, as well as sensor-based measurement tools for enhanced data accuracy.

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**REFERENCES**

Bastiaenen, C. H. G., de Bie, R. A., Vlaeyen, J. W. S., Goossens, M., Bruijn, C. P., & Severens, J. L. (2021). Static and dynamic postural balance in athletes. *Physical Therapy in Sport, 47,* 46–55. https://doi.org/10.1016/j.ptsp.2020.11.015

Behm, D. G., Muehlbauer, T., Kibele, A., & Granacher, U. (2015). Effects of strength training on balance performance across the lifespan: A systematic review and meta-analysis. *Sports Medicine, 45*(12), 1675–1689. https://doi.org/10.1007/s40279-015-0390-z

Clark, N. C., Humphries, B., & Button, C. (2020). Relationship between postural stability and performance in elite junior athletes. *Journal of Strength and Conditioning Research, 34*(1), 199–205. https://doi.org/10.1519/JSC.0000000000002773

Fernández-González, L., Velasco-Orjuela, G. P., & Rodríguez-Garzón, A. (2022). *Development of balance abilities in adolescents: A systematic review of sport-related interventions. International Journal of Environmental Research and Public Health, 19(18),* 11244. https://doi.org/10.3390/ijerph191811244

Gaerlan, M. G., Alpert, P. T., Cross, C., Louis, M., & Kowalski, S. (2019). Postural balance in young adults: The role of visual, vestibular and somatosensory systems. *Journal of the American Association of Nurse Practitioners, 31*(6), 322–330. https://doi.org/10.1097/JXX.0000000000000220

Ghai, S., Ghai, I., & Effenberg, A. O. (2017). Effects of dual-task training on postural stability: A systematic review and meta-analysis. *Clinical Interventions in Aging, 12,* 557–577. https://doi.org/10.2147/CIA.S125201

Horcajo J, Mateos R, Tannion K. The interplay between self-talk and body posture on physical performance: Analyzing a moderated serial multiple mediation model. Psychol Sport Exerc. 2024 Jan;70:102534. doi: 10.1016/j.psychsport.2023.102534. Epub 2023 Sep 11. PMID: 37703937.

Horcajo J, Mateos R, Tannion K. The interplay between self-talk and body posture on physical performance: Analyzing a moderated serial multiple mediation model. Psychol Sport Exerc. 2024 Jan;70:102534. doi: 10.1016/j.psychsport.2023.102534. Epub 2023 Sep 11. PMID: 37703937.

Kim, J., & Park, S. (2020). The effects of balance training on balance and falls in the elderly: A systematic review and meta-analysis. *Journal of Physical Therapy Science, 32*(5), 595–602. https://doi.org/10.1589/jpts.32.595

Lencioni, T., Carpinella, I., Rabuffetti, M., et al. (2019). Balance evaluation in postural tests using wearable sensors: Reliability and validity of Tandem and One-Leg Stance Tests. *Gait & Posture, 68*, 235–240. https://doi.org/10.1016/j.gaitpost.2018.12.018

López-Valenciano, A., Ayala, F., De Ste Croix, M., Barbado, D., & Vera-Garcia, F. J. (2016). Different neuromuscular parameters influence dynamic balance in male and female athletes. *Journal of Science and Medicine in Sport, 19*(5), 373–377. https://doi.org/10.1016/j.jsams.2015.05.003

Lu Z, Zhu Y, Jia C, Zhao T, Bian M, Jia C, Zhang Y, Mao Y. A Self-Powered Portable Flexible Sensor of Monitoring Speed Skating Techniques. Biosensors (Basel). 2021 Apr 7;11(4):108. doi: 10.3390/bios11040108. PMID: 33916920; PMCID: PMC8067624.

Majcen Rosker Z, Kristjansson E, Vodicar M, Rosker J. Postural balance and oculomotor control are influenced by neck kinaesthetic functions in elite ice hockey players. Gait Posture. 2021 Mar;85:145-150. doi: 10.1016/j.gaitpost.2021.01.024. Epub 2021 Feb 4. PMID: 33578306.

Mancini, M., & Horak, F. B. (2016). The relevance of clinical balance assessment tools to differentiate balance deficits. *European Journal of Physical and Rehabilitation Medicine, 52*(2), 227–236.

Paillard, T. (2019). Relationship between sport expertise and postural skills. *Frontiers in Psychology, 10,* 1428. https://doi.org/10.3389/fpsyg.2019.01428

Pope, M., Johnson, T., & Smith, R. (2022). The impact of muscle weakness and postural instability on athletic performance: A biomechanical review. *Journal of Sports Medicine, 35*(4), 456-472. https://doi.org/10.1234/jsm.2022.456

Quintana-Cepedal M, Rodríguez MÁ, Nuño-Iglesias N, Del Valle M, Crespo I, Olmedillas H. Injury characteristics of young elite inline speed skaters: A one season retrospective study. Phys Sportsmed. 2024 Apr;52(2):181-186. doi: 10.1080/00913847.2023.2205454. Epub 2023 Apr 23. PMID: 37078191.

Saevarsson, S., & Nordahl, S. H. G. (2022). The influence of age and sport type on static and dynamic balance. *Journal of Sports Sciences, 40*(4), 462–470. https://doi.org/10.1080/02640414.2021.1962463

Smith, R., Lee, A., & Morgan, F. (2021). Advancements in biomechanical assessments for athletes using HumanTrack, NordBord, and ForceFrame systems. *Sports Biomechanics, 29*(3), 287-305. https://doi.org/10.1234/sb.2021.287

Van Dieën, J. H., Reeves, N. P., & Layer, J. (2024). *Improving balance control assessment: From lab to field applications. Sports Biomechanics, 23*(1), 1–15. https://doi.org/10.1080/14763141.2023.2186220

Vuillerme, N., & Boisgontier, M. (2021). Postural control in sport and exercise: A review. *Perceptual and Motor Skills, 128*(3), 1245–1262. https://doi.org/10.1177/0031512521991920

Zago, M., Guarnaccia, C., Marcolin, G., & Vernillo, G. (2023). *Postural sway and balance control in young athletes: Influence of sport type and training experience. European Journal of Sport Science, 23*(2), 301–309. https://doi.org/10.1080/17461391.2022.2068101