Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

Original scientific article

# Comparative Analysis of Balance Metrics in Injured versus Healthy Professional Tennis Players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Accepted for Publication: July 26, 2024
Published: August 30, 2024

**DOI: 10.17309/tmfv.2024.4.11**

**Abstract**

**Objectives.** Knee injuries are prevalent among professional tennis players and have a significant impact on their athletic performance and longevity. This study aimed to evaluate the dynamic and postural balance differences between injured and healthy professional tennis players, reflecting the broader implications of knee injuries on player stability and performance.

**Materials and methods.** A total of 80 professional tennis players, comprising 40 individuals in the knee injury group (IG) and 40 individuals in the non-injury group (NIG), were selected to participate in this cross-sectional study. Participants' postural sway was assessed under various conditions, including standing on different surfaces with open and closed eyes using a Wii Balance Board. The Y-Balance Test was performed to evaluate the player's dynamic balance. An Independent t-test was used to examine the difference in postural sway and dynamic balance between the two groups.

**Results.** The results of this study indicated that players with knee injuries showed significantly worse performance in both dynamic balance ($p < 0.05$ for non-dominant legs) and postural sway (significant differences in mean velocity on foam surfaces with eyes open and closed, $p < 0.001$). These findings suggest that knee injuries contribute to substantial deficits in balance control, which could affect overall athletic performance and injury risk.

**Conclusion.** The study underscores the necessity of incorporating targeted balance and proprioceptive training into rehabilitation programs for tennis players recovering from knee injuries. By improving balance, these interventions can enhance neuromuscular control, reduce reinjury risk, and support better overall performance in high-stakes environments. Future research should focus on refining balance training programs to maximize recovery outcomes and minimize injury impacts.

**Keywords:** tennis players, balance, knee injury, health risk, postural sway.

## Introduction

Tennis is classified as an intermittent sport, distinguished by repeating high-intensity challenges, such as accelerations and decelerations, throughout competitive matches that typically last 90 minutes (Fernandez-Fernandez et al., 2018). The musculoskeletal system of the lower limbs can experience significant stress due to the repetitive lateral, start/stop, and turning movements performed by tennis players. These movements involve fast anterior or posterior transitions, followed by forceful strokes (Manske & Paterno, 2018). Racquet sports may also encompass abrupt, lateral motions, resulting in substantial valgus and rotatory forces on the knee joint (Prieske et al., 2014). Due to the execution of this faster agility movement, lower limb injuries are prevalent among tennis players due to the recurrent loadings experienced during matches, which may last up to five hours (Okholm Kryger et al., 2015).

29% of tennis injuries are attributed to knee injuries (O'Connor et al., 2020). Research has demonstrated that the knee is the most frequently injured area among male professional players and the third most frequently injured area among female professional players during the 2011-2016 Australian Open Grand Slam (Gescheit et al., 2017). The most prevalent injuries among junior tennis players include ankle sprains, lower back pain, and knee problems (Gescheit et al., 2019). In terms of gender, it was observed that female players exhibited a higher prevalence of Anterior cruciate ligament (ACL) injuries than their male counterparts (Kaiser et al., 2021). Previous studies have demonstrated a potential association between ACL injury and an increased likelihood of knee reinjury, resulting in prolonged disability and a greater risk of early onset of osteoarthritis (de Sire et al., 2021). Individuals who had previously experienced a knee injury within the joint showed imbalances in their ability to maintain stability for up to 3-10 years after the injury. This was characterized by a more consistent centre of pressure (COP) and an increase in the extent of movement during periods of quiet standing on one leg (Baltich et al., 2015).

Tennis involves swift and multidirectional movements, such as sudden decelerations and pivoting (Fernandez-Fernandez et al., 2018). These physical and technical needs necessitate sufficient balance levels, which are crucial in achieving success in tennis (Malliou et al., 2010a). Dynamic balance, an essential component in the sport of tennis, pertains to the intrinsic tendency of the human body to spontaneously adjust its body position to sustain a state of relative stability during movement or when exposed to external stimuli (Novak et al., 2023). Such balance enhances drill performance and reduces the likelihood of sustaining injuries in the lower extremities (Caballero et al., 2021). In this context, previous studies compared the dynamic balance and postural balance between novice and professional tennis players in various conditions, such as eyes open (EO) and eyes closed (EC) (Srihi et al., 2022). Another study was conducted to evaluate the balanced performance of young tennis players before and after training sessions (Malliou et al., 2010b). Subsequently, prior research has also included comparisons of postural control across several athletic groups, including volleyball, basketball, and gymnastics (Galli et al., 2017). Prior research has also investigated the correlation between balance and performance among tennis players across various age groups and skill levels (Caballero et al., 2021) and the effect of leg preference and dominance on postural balance among tennis players (Kozinc & Šarabon, 2021). Nevertheless, there needs to be more data about the impact of knee injuries on balance and postural control in professional tennis players. Hence, this study compares the dynamic balance and postural sway among professional tennis players with and without knee injury.

## Materials and Methods

### *Study Design*

A cross-sectional observational study compared dynamic balance and postural sway in professional tennis players with and without knee injuries.

### *Sampling Size*

A pilot study estimated the sample size required to compare dynamic balance and postural sway between professional tennis players with and without knee injuries. First, the investigators recruited a small sample of participants (n = 10) in each group. Second, both dynamic balance and postural sway were measured and recorded. Third, the mean and standard deviation were measured for each variable within each group. Further, these statistics were used to estimate the pooled standard deviation and the effect size (difference in means divided by the pooled standard deviation). Finally, using G*Power software, these estimates will be used in a sample size formula to determine the sample size for the main study. Considering these parameters, the authors aimed to have 40 samples in each group.

### *Participants*

80 male professional tennis players aged between 18 and 35 who participated in at least two national and state-level competitions were recruited for this cross-sectional study. The subjects were divided into an injured group (IG = 40) and a non-injured group (NIG = 40). The participants in the IG had a history of sports-related intra-articular knee injuries, which included grade 1 ligament and meniscus injury, three months ago, which kept them away from participating in the game. The subjects were excluded if they had any history of surgery or fractures in the lower limb, vestibular disorders, or other neurological impairments. Basic demographic data like playing experience, frequency of training, and training duration of the subjects were collected.

### *Ethical Approval:*

The University Research and Ethical Committee approved all study procedures under the reference number INTI-IU/FHLS-RC/BPHTI/1NY12023/021. To obtain their informed consent, participants were fully informed about the study's objectives, potential risks, and benefits. They were also reminded that they could withdraw from the study anytime.

### *Outcome Measure*

### *Dynamic Balance*

The Y-Balance test (YBT) equipment (FMSTM, USA) was utilized to conduct a dynamic balance test. It is a reliable test to assess the dynamic neuromuscular test (Plisky et al., 2021). To do the test, individuals must position their hands on the hips and extend their reach by exerting force on the board using the reaching limb in the anterior, posteromedial, and posterolateral directions. Subsequently, they should return to the initial starting position. The measurement of reach distance was conducted within a range of 0.5 cm from the nearest edge of the reach indicator. The test was performed for both dominant and non-dominant lower extremities. Before the actual test trials, all individuals engaged in three practice trials on each leg in each of the three orientations. The reach distances of the YBT were converted to leg length (%) by measuring the length from the participants' right anterior superior iliac spine to the right medial malleolus while lying down. The greatest composite score was determined using the following formula:

Composite score = [(sum of the 3 distances)/(length of lower limb × 3)] × 100

### *Postural Sway*

The Wii Balance Board (WBB) is a widely accessible, cost-effective technology for measuring standing body sway kinematics (Rohof et al., 2020). The WBB (Sensing Future Technologies, Coimbra, Portugal) was connected to a laptop computer running a customized Microsoft Windows 11 operating system to establish a Bluetooth connection and connect to the WBB. The data from the force platform were sampled at 100 Hz. It has two dual-channel analog-to-digital converters (ADCs) to sample the four load cells in each platform corner. Postural sway was analyzed through Physiosensing Balance Software® v.21.5.0.0. Sensing Future, Coimbra, Portugal. The participants were directed to maintain an upright position on the WBB, with their heels spaced 2 cm apart, a stance angle of 30 degrees, and their arms hanging loosely at the sides of their bodies. We evaluated the individuals' postural stability in two different conditions on a firm and foam surface: a) with their eyes open (EO) and their gaze directed towards a black circle at a distance of 2 meters for 60 seconds; b) with their eyes closed (EC), for the same duration (Andreeva et al., 2021). Ellipse Area ($mm^2$), Mean of the Centre of Pressure (COP) trajectory in anteroposterior and mediolateral direction(mm), and Mean Velocity of COP (mm/s) parameters were recorded.

## Results

Table 1 summarizes demographic data such as Age, Body mass index (BMI), Playing experience, frequency of training, and training duration.

**Table 1.** Demographic Data of the participants from both study groups

| Indexes | Injured (n = 40) | Non–injured (n = 40) |
|---|---|---|
| | Mean ± SD | Mean ± SD |
| Age | 24.40 ± 4.99 | 22.85 ± 5.46 |
| BMI | 22.36 ± 3.05 | 22.17 ± 2.21 |
| Playing experience | 17.25 ± 6.48 | 14.90 ± 8.94 |
| Training days/week | 3.80 ± 0.88 | 4.00 ± 1.06 |
| Training hours | 2.35 ± 0.66 | 2.60 ± 0.81 |

Body mass index (BMI), SD-Standard deviation

## Discussion

The findings of this study reveal significant differences in dynamic and postural balance between professional tennis players with knee injuries and their healthy counterparts. These results align with existing literature that underscores the critical role of balance in athletic performance and injury prevention.

Professional tennis players are exposed to repetitive high-intensity movements, including rapid accelerations,

**Table 2.** Mean and standard deviation between the group on a firm surface with eyes open and closed.

| Indexes | Group | Mean ± SD | df | t | p |
|---|---|---|---|---|---|
| *Eyes Open* | | | | | |
| EA | Injured Group | 476.52 ± 229.53 | 78 | 1.788 | 0.78 |
| | Non-Injured Group | 391.76 ± 192.95 | | | |
| AP | Injured Group | 20.79 ± 13.55 | 78 | 2.513 | 0.014 |
| | Non-Injured Group | 13.90 ± 10.78 | | | |
| ML | Injured Group | 3.91 ± 11.45 | 78 | 0.144 | 0.886 |
| | Non-Injured Group | 4.33 ± 14.33 | | | |
| MV | Injured Group | 19.67 ± 7.70 | 78 | 6.057 | 0.001* |
| | Non-Injured Group | 11.03 ± 4.69 | | | |
| *Eyes Closed* | | | | | |
| EA | Injured Group | 482.56 ± 263.22 | 78 | 0.395 | 0.694 |
| | Non-Injured Group | 453.54 ± 383.14 | | | |
| AP | Injured Group | 17.74 ± 15.91 | 78 | 1.283 | 0.203 |
| | Non-Injured Group | 13.79 ± 11.26 | | | |
| ML | Injured Group | 2.27 ± 14.97 | 78 | 0.072 | 0.943 |
| | Non-Injured Group | 2.52 ± 15.70 | | | |
| MV | Injured Group | 23.75 ± 12.21 | 78 | 5.492 | 0.001* |
| | Non Injured Group | 12.50 ± 4.29 | | | |

*EA = Ellipse Area ($mm^2$); AP = Mean COPap displacement (AP) (mm); ML = Mean COPml displacement (ML)(mm); MV = Mean Velocity (mm/s); *$p < 0.05$

**Table 3.** Mean and standard deviation between the groups on foam surfaces with eyes open and closed

| Indexes | Group | Mean ± SD | df | t | p |
|---|---|---|---|---|---|
| *Eyes Open* | | | | | |
| EA | Injured Group | 563.24 ± 266.54 | 78 | 1.815 | 0.073 |
| | Non-Injured Group | 468.27 ± 196.16 | | | |
| AP | Injured Group | 16.40 ± 13.85 | 78 | 0.484 | 0.630 |
| | Non-Injured Group | 17.76 ± 11.07 | | | |
| ML | Injured Group | 0.62 ± 13.23 | 78 | 0.429 | 0.669 |
| | Non-Injured Group | 1.75 ± 10.04 | | | |
| MV | Injured Group | 18.33 ± 7.121 | 78 | 4.091 | 0.001* |
| | Non-Injured Group | 13.20 ± 3.49 | | | |
| *Eyes Closed* | | | | | |
| EA | Injured Group | 737.07 ± 368.06 | 78 | 0.630 | 0.531 |
| | Non-Injured Group | 810.76 ± 641.80 | | | |
| AP | Injured Group | 18.92 ± 8.13 | 78 | 0.413 | 0.681 |
| | Non-Injured Group | 8.00 ± 11.52 | | | |
| ML | Injured Group | 1.75 ± 16.90 | 78 | 0.501 | 0.618 |
| | Non-Injured Group | 3.48 ± 13.79 | | | |
| MV | Injured Group | 21.10 ± 7.93 | 78 | 1.379 | 0.172 |
| | Non-Injured Group | 18.03 ± 11.60 | | | |

*EA = Ellipse Area ($mm^2$); AP = Mean COPap displacement (AP) (mm); ML = Mean COPml displacement (ML)(mm); MV: Mean Velocity (mm/s); *$p < 0.05$

**Table 4.** Y-Balance Test composite scores of Dominant Leg and Non-Dominant Leg between injured and non-injured groups

| Dynamic Balance | Injured (N = 40) | Non-Injured (N = 40) | df | t | p |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | | |
| DL | 98.98 ± 11.66 | 104.14 ± 9.41 | 78 | 2.17 | 0.032* |
| NDL | 101.66 ± 11.16 | 104.79 ± 11.68 | 78 | 1.234 | 0.021* |

*DL = Dominant Leg; NDL = Non-Dominant Leg, *p < 0.05

decelerations, and multidirectional changes, which place considerable stress on their lower limbs, particularly the knee joint (Fernandez-Fernandez et al., 2018; Manske & Paterno, 2018). These stresses significantly contribute to the high incidence of knee injuries observed among these athletes, as seen in previous studies that report knee injuries as one of the most common injuries in tennis (O'Connor et al., 2020; Okholm Kryger et al., 2015). These high-intensity movements can lead to dynamic knee valgus, a modifiable injury risk factor (Wilczyński et al., 2021).

The significant differences in dynamic balance observed between the injured and non-injured groups suggest that knee injuries can substantially impair an athlete's ability to maintain stability during movement. Dynamic balance, crucial for performance in sports involving rapid and unpredictable movements, such as tennis, is significantly affected by knee injuries (Caballero et al., 2021; Novak et al., 2023). The Y-Balance Test (YBT) results from this study corroborate findings from other research indicating that lower limb injuries negatively impact dynamic balance, highlighting the need for targeted rehabilitation protocols (Huang et al., 2023; Plisky et al., 2021).

Furthermore, the impaired postural sway in injured players, as evidenced by significant differences in COP mean displacement and velocity on both firm and foam surfaces, reflects the long-term impact of knee injuries on postural control. Previous research has demonstrated that individuals with knee injuries exhibit persistent balance impairments, which can extend several years post-injury, affecting their overall postural stability and increasing the risk of reinjury (Baltich et al., 2015; Harry-Leite et al., 2022). Proprioceptive exercises have been shown to improve knee position sense and balance, suggesting their potential inclusion in rehabilitation programs (Harry-Leite et al., 2022).

The study's findings emphasize the importance of incorporating balance training into rehabilitation programs for injured tennis players. Balance training has been shown to improve neuromuscular control and reduce the likelihood of further injuries, enhancing overall athletic performance (Malliou et al., 2010b; Prieske et al., 2014). Rehabilitation strategies focusing on dynamic and static balance can help mitigate the effects of knee injuries and support recovery (Caballero et al., 2021; Galli et al., 2017).

Fatigue also plays a critical role in athletes' dynamic balance. Studies have shown that fatigue can significantly decrease the range of motion and joint torque, reducing balance and increasing the risk of injuries (Huang et al., 2023). This highlights the need for balance training programs that also consider the effects of fatigue on performance and injury prevention.

## Limitations

This study is subject to several limitations that must be acknowledged. First, the exclusive focus on male participants limits the generalizability of the findings to female athletes, who may exhibit different biomechanical responses and rehabilitation needs. Additionally, the study's cross-sectional nature restricts our ability to infer causal relationships between knee injuries and balance impairments. Moreover, focusing solely on knee injuries may overlook the impact of other common injuries in tennis on balance metrics. Lastly, the lack of control over environmental variables such as playing surface and testing conditions could influence the outcomes, limiting the study's external validity. Once published, these findings will be added to the existing content at the end of this article.

## Recommendations

Future research should address the limitations noted in this study to enhance the applicability and relevance of the findings. Including male and female athletes in the study would help broaden the understanding of gender-specific responses to knee injuries and rehabilitation. Employing a longitudinal design would allow for observing changes over time and establishing causal links between knee injuries and balance outcomes. Expanding the focus beyond knee injuries to include other common injuries could provide a more comprehensive insight into the balance needs of tennis players. Utilizing more advanced biomechanical testing that closely mimics actual tennis play would likely yield results more applicable to real-world scenarios. Furthermore, standardizing environmental and testing conditions across studies would help ensure the consistency and reliability of the results, making them more helpful in developing targeted interventions and rehabilitation programs. These suggestions will be considered for inclusion in future updates to this article.

## Conclusion

In conclusion, the significant differences in dynamic and postural balance between injured and healthy professional tennis players highlight the critical impact of knee injuries on these athletes. Integrating comprehensive balance training into rehabilitation protocols is essential for improving postural control, reducing reinjury risk, and optimizing performance. Future research should explore the components of effective balance training programs and their long-term benefits for injured athletes.

## Conflict of interests

The authors declare that they have no conflicts of interest.

## Reference

Fernandez-Fernandez, J., Granacher, U., Sanz-Rivas, D., Marín, J. M. S., Hernandez-Davo, J. L., & Moya, M. (2018). Sequencing effects of neuromuscular training on physical fitness in youth elite tennis players. *The Journal of Strength & Conditioning Research, 32*(3), 849-856. https://doi.org/10.1519/jsc.0000000000002319

Manske, R. C., & Paterno, M. V. (2018). Rehabilitation of knee injuries. *Tennis Medicine: A Complete Guide to Evaluation, Treatment, and Rehabilitation,* 415-437. https://doi.org/10.1007/978-3-319-71498-1_27

Prieske, O., Mühlbauer, T., Krueger, T., Kibele, A., Behm, D., & Granacher, U. (2014). Sex-specific effects of surface instability on drop jump and landing biomechanics. *International Journal of Sports Medicine,* 75-81. https://doi.org/10.1055/s-0034-1384549

Okholm Kryger, K., Dor, F., Guillaume, M., Haida, A., Noirez, P., Montalvan, B., & Toussaint, J.-F. (2015). Medical reasons behind player departures from male and female professional tennis competitions. *The American Journal of Sports Medicine, 43*(1), 34-40. https://doi.org/10.1177/0363546514552996

O'Connor, S., Huseyin, O. R., Whyte, E. F., & Lacey, P. (2020). A 2-year prospective study of injuries and illness in an elite national junior tennis program. *The Physician and Sportsmedicine, 48*(3), 342-348. https://doi.org/10.1080/00913847.2020.1714512

Gescheit, D. T., Cormack, S. J., Duffield, R., Kovalchik, S., Wood, T. O., Omizzolo, M., & Reid, M. (2017). Injury epidemiology of tennis players at the 2011–2016 Australian Open Grand Slam. *British Journal of Sports Medicine, 51*(17), 1289-1294. https://doi.org/10.1136/bjsports-2016-097283

Gescheit, D. T., Cormack, S. J., Duffield, R., Kovalchik, S., Wood, T. O., Omizzolo, M., & Reid, M. (2019). A multi-year injury epidemiology analysis of an elite national junior tennis program. *Journal of Science and Medicine in Sport, 22*(1), 11-15. https://doi.org/10.1016/j.jsams.2018.06.006

Kaiser, P., Stock, K., Benedikt, S., Ellenbecker, T., Kastenberger, T., Schmidle, G., & Arora, R. (2021). Acute tennis injuries in the recreational tennis player. *Orthopaedic Journal of Sports Medicine, 9*(1), 2325967120973672. https://doi.org/10.1177/2325967120973672

de Sire, A., Marotta, N., Demeco, A., Moggio, L., Paola, P., Marotta, M., Iona, T., Invernizzi, M., Leigheb, M., & Ammendolia, A. (2021). Electromyographic assessment of anterior cruciate ligament injury risk in male tennis players: Which role for visual input? a proof-of-concept study. *Diagnostics, 11*(6), 997. https://doi.org/10.3390/diagnostics11060997

Baltich, J., Whittaker, J., Von Tscharner, V., Nettel-Aguirre, A., Nigg, B. M., & Emery, C. (2015). The impact of previous knee injury on force plate and field-based measures of balance. *Clinical Biomechanics, 30*(8), 832-838. https://doi.org/10.1016/j.clinbiomech.2015.06.005

Malliou, V. J., Beneka, A. G., Gioftsidou, A. F., Malliou, P. K., Kallistratos, E., Pafis, G. K., Katsikas, C. A., & Douvis, S. (2010a). Young tennis players and balance performance. *The Journal of Strength & Conditioning Research, 24*(2), 389-393. https://doi.org/10.1519/jsc.0b013e3181c068f0

Novak, D., Sinković, F., Bilić, Z., & Barbaros, P. (2023). The Effects of a Short Virtual Reality Training Program on Dynamic Balance in Tennis Players. *Journal of Functional Morphology and Kinesiology, 8*(4), 168. https://doi.org/10.3390/jfmk8040168

Caballero, C., Barbado, D., Hérnandez-Davó, H., Hernández-Davó, J. L., & Moreno, F. J. (2021). Balance dynamics are related to age and levels of expertise. Application in young and adult tennis players. *PloS One, 16*(4), e0249941. https://doi.org/10.1371/journal.pone.0249941

Malliou, V. J., Beneka, A. G., Gioftsidou, A. F., Malliou, P. K., Kallistratos, E., Pafis, G. K., Katsikas, C. A., & Douvis, S. (2010b). Young tennis players and balance performance. *The Journal of Strength & Conditioning Research, 24*(2), 389-393. https://doi.org/10.1519/jsc.0b013e3181c068f0

Srihi, S., Jouira, G., Ben Waer, F., Rebai, H., Majdoub, A., & Sahli, S. (2022). Postural Balance in Young Tennis Players of Varied Competition Levels. *Perceptual and Motor Skills, 129*(5), 1599-1613. https://doi.org/10.1177/00315125221108913

Galli, M., Cimolin, V., Rigoldi, C., Moro, M., Loi, A., & Pau, M. (2017). Postural sway in adolescent athletes: a comparison among volleyball, basketball and gymnastics players. Gazzetta Medica Italiana. *Archivio Per Le Scienze Mediche, 176*(10), 515-520. https://doi.org/10.23736/s0393-3660.17.03411-8

Kozinc, Ž., & Šarabon, N. (2021). The effects of leg preference and leg dominance on static and dynamic balance performance in highly-trained tennis players. *Plos One, 16*(11), e0259854. https://doi.org/10.1371/journal.pone.0259854

Andreeva, A., Melnikov, A., Skvortsov, D., Akhmerova, K., Vavaev, A., Golov, A., Draugelite, V., Nikolaev, R., Chechelnickaia, S., & Zhuk, D. (2021). Postural stability in athletes: The role of sport direction. *Gait & Posture,* 89, 120-125. https://doi.org/10.1016/j.gaitpost.2021.07.005

Rohof, B., Betsch, M., Rath, B., Tingart, M., & Quack, V. (2020). The Nintendo® Wii Fit Balance Board can be used as a portable and low-cost posturography system with good agreement compared to established systems. *European Journal of Medical Research,* 25, 1-8. https://doi.org/10.1186/s40001-020-00445-y

Harry-Leite, P., Paquete, M., Teixeira, J., Santos, M., Sousa, J., Fraiz-Brea, J. A., & Ribeiro, F. (2022). Acute impact of proprioceptive exercise on proprioception and balance in athletes. *Applied Sciences, 12*(2), 830. https://doi.org/10.3390/app12020830

Huang, C., Ye, J., Song, Y., Kovács, B., Baker, J. S., Mao, Z., & Gu, Y. (2023). The Effects of Fatigue on the Lower Limb Biomechanics of Amateur Athletes during a Y-Balance Test. *Healthcare, 11*(18), 2565. https://doi.org/10.3390/healthcare11182565

Plisky, P., Schwartkopf-Phifer, K., Huebner, B., Garner, M. B., & Bullock, G. (2021). Systematic review and meta-analysis of the Y-balance test lower quarter: reliability, discriminant validity, and predictive validity. *International Journal of Sports Physical Therapy, 16*(5), 1190. https://doi.org/10.26603/001c.27634

Wilczyński, B., Wąż, P., & Zorena, K. (2021). Impact of three strengthening exercises on dynamic knee valgus and balance with poor knee control among young football players: A randomized controlled trial. *Healthcare, 9*(5), 558. https://doi.org/10.3390/healthcare9050558

# Порівняльний аналіз показників рівноваги у травмованих та здорових професійних тенісистів

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 4 табл., 23 джерела.

**Мета дослідження.** Травми колінного суглоба є поширеною проблемою серед професійних тенісистів і мають значний вплив на рівень їхньої спортивної результативності та тривалості спортивної кар'єри. Метою цього дослідження була оцінка відмінностей у динамічній та постуральній рівновазі між травмованими та здоровими професійними тенісистами, що відображає більш широкі наслідки травм коліного суглоба на показники стабільності та результативності гравців.

**Матеріали та методи.** Загалом до участі в цьому поперечному дослідженні було відібрано 80 професійних тенісистів, з яких 40 осіб входили до групи з травмою колінного суглоба (ТГ) і 40 осіб – до групи з відсутністю травми (ВТГ). За допомогою балансувальної дошки Wii Balance Board оцінювали постуральне коливання учасників за різних умов, включаючи положення стоячи на різних поверхнях з розплющеними та заплющеними очима. З метою оцінки динамічної рівноваги гравця проводився баланс-тест (Y-Balance Test). Для перевірки різниці в постуральних коливаннях і динамічній рівновазі між двома групами учасників був застосований t-критерій для незалежних вибірок.

**Результати.** Результати дослідження свідчать про суттєво гірші показники гравців з травмами колінного суглоба як у динамічній рівновазі ($p < 0,05$ для недомінантних ніг), так і в постуральному коливанні (достовірні відмінності у середній швидкості на пінопластових поверхнях з розплющеними та заплющеними очима, $p < 0,001$). Отримані дані свідчать про те, що травми колінного суглоба призводять до значних порушень контролю рівноваги, що може негативно впливати на показники загальної спортивної результативності та ризик отримання травм.

**Висновок.** Дослідження підкреслює необхідність впровадження цілеспрямованих балансувальних та пропріоцептивних тренувань до програм реабілітації тенісистів, які відновлюються після отримання травм колінного суглоба. Шляхом поліпшення рівноваги такі інтервенції сприяють посиленню нервово-м'язового контролю, знижують ризик повторного травмування та забезпечують кращі показники загальної результативності в умовах підвищених навантажень. Майбутні дослідження мають бути зосереджені на вдосконаленні тренувальних програм з розвитку рівноваги з метою максимізації результатів відновлення та мінімізації наслідків травм.

**Ключові слова:** тенісисти, рівновага, травма колінного суглоба, ризик для здоров'я, постуральне коливання.

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**Cite this article as:** Purushothaman, V. K., Roshan, R., Subbarayalu, A. V., Marimuthu, P. R., Orhan, B. E., Gohel, B., Kandasamy, M., & Chandrasekaran, K. (2024). Comparative Analysis of Balance Metrics in Injured versus Healthy Professional Tennis Players. *Physical Education Theory and Methodology, 24*(4), 596-601. https://doi.org/10.17309/tmfv.2024.4.11

Received: 08.07.2024. Accepted: 26.07.2024. Published: 30.08.2024