The European Proceedings of
Social & Behavioural Sciences
EpSBS

Future Academy ISSN: 2357-1330

https://dx.doi.org/10.15405/epsbs.2019.02.91

ICPESK 2018
International Congress of Physical Education, Sports and Kinetotherapy. Education and Sports Science in the 21st Century, Edition dedicated to the 95th anniversary of UNEFS

ON-COURT STATIC BALANCE EVALUATION OF YOUNG TENNIS PLAYERS

Rodica Prodan (a)*, Emilia Florina Grosu (a)
*Corresponding author

(a) Babes-Bolyai University, 7 Pandurilor St., Cluj-Napoca, Romania
(b) Babes-Bolyai University, 7 Pandurilor St., Cluj-Napoca, Romania,

Abstract

The purpose of this study was to examine the outcome of some tennis drills sessions on the static balance performance of young tennis players. The study was conducted for 12 months on 24 amateur tennis players (age 12 ± 2 years; body mass 47 ± 8 kg; body height 155 ± 12 cm) participating twice per week in a 2-hour tennis class. Balance performance was appraised before and immediately after a tennis training session (pre-training and post-training, respectively). The training session proposed by the authors implied three static balance training exercises performed individually and in pairs. Balance assessment was performed with the Nintendo Wii Board (®) and the Wii Fit software. Also, dynamometric measurements of peak isokinetic moment in the knee flexors and extensors were performed pre and post tennis training sessions to quantify the degree of muscle fatigue induced by the tennis training session. To evaluate the differences in balance and isokinetic performance between pre and post tennis training sessions, one-way analysis of variance with repeated measurements was used. The data analysis revealed no statistically significant differences in balance performance, but exposed significant differences in the knee joint moment production between pre and post tennis training measures. The Nintendo Wii Board seems to be a dependable and accurate low-priced device that could be used in field settings on subjects of various ages. Future research is necessary to scrutinise more the inter- and intra-subject variability.

Keywords: Tennis, balance, training, evaluation. .

https://dx.doi.org/10.15405/epsbs.2019.02.91
Corresponding Author: Rodica Prodan
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

1. Introduction

Tennis is a sport that has gained a large audience in the last five years in Romania, due to the great performance of a group of determined young players that climbed onto the top 100 Players rankings, both ATP and WTA. Even it is not a contact sport, frequent injuries in the lower extremities occur, temporarily incapacitating the players, regardless of their age. After the keyword "prevention" confined in the rehabilitation specialists' minds, it was materialised in some specific drills with specific goals. For example, to decline muscle stiffness, different stretching exercises were suggested, to restore muscle imbalances, strengthening exercises were tendered, and to improve proprioception (described by Sherrington, in 1906, as the awareness of body segment positions and orientations), various balance exercises were proposed. Recent studies on rehabilitation support the idea that practicing balance exercises improves proprioception and avoids injuries. The proprioception of lower limbs is significant in the proper maintenance of balance in tennis, due to the specificity of the game. Of utmost importance is the information regarding the even weight distribution on the two feet and whether the weight pressure is upon the rearfoot or the forefoot. Because tennis skills chain some complex movements, the player needs to possess high balance abilities. Moreover, since tennis is an explosive sport, it involves multiaxial movements and short bursts of action. Physical condition in tennis requires some elements like: explosion, speed, agility, balance. So, to be an effective tennis player on the court and also to perform better the training drills, one must develop balance as a fundamental ability that can be maintained for games lasting 2-3 hours.

2. Problem Statement

Considered to be a demanding game with complex motor movements, tennis needs perfect coordination between eyes, hands and legs.

Also, there is a demand for available, inexpensive devices for the dependable and accurate assessment of balance conduct in both testing room and outdoor on-court environments.

3. Research Questions

What effect has the tennis training session on the balance performance of young tennis players?

Is there a technical possibility to perform valid on-field evaluations without the necessity to repeat them in the laboratory?

Are there any differences in the knee-joint isokinetic moment between pre and post tennis training evaluations?

4. Purpose of the Study

The present study evaluates the individual balance ability before and after a regular tennis training class. Moreover, it will clarify if it is necessary to include balance exercises into the regular tennis training programs.

https://dx.doi.org/10.15405/epsbs.2019.02.91
Corresponding Author: Rodica Prodan
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

5. Research Methods

5.1. Static balance evaluation

The study was conducted for 12 months on 24 amateur tennis players (age 12 ± two years; body mass 47 ± 8 kg; body height 155 ± 12 cm) participating twice per week in a 2-hour in a tennis class. All participants had been free of lower limb injuries in the previous two years. They all signed an informed consent document prior to the investigation. The research was approved by the institutional committee of human subjects where the study was conducted. Each training session had 120 minutes and comprised 10 minutes of active warm-up exercises, drills for groundstrokes, volley, practicing serves and returns. In the last 30 minutes, they played games. The goal of the training class was to focus on both the technique and tactics of the game. Regarding technical training, the objectives were: to develop basic tennis strokes, to control the ball direction (down the line, crosscourt), to control the ball depth (long, middle, short balls) and, last but not least, the speed of the ball. The tactics was focused on defining an individual profile for each player (aggressive baseliner, all around, serve and volley).

Balance and dynamometric evaluations were performed at every meeting, before and after the same tennis class.

Balance assessment was performed with a balance board provided by Amiga, the Nintendo Wii Board®, together with the Wii Fit Software® program. The assessment implied four distinct balance evaluations: standing on both legs with eyes open, standing only on the dominant leg, standing only on the non-dominant leg and standing on both legs with eyes shut. Each test had 20-second duration, counted with a digital stopwatch. Between the tests, a break of 30 seconds was provided. The investigated parameter was the Centre of Pressure path Length (COPL).

Standing balance control in kids, compared to grown-ups, has some differences. Also, different body size proportions in kids and grown-ups and "upper-heaviness" of children yield a relatively higher centre of mass location (Groppel, 2003). Hence, balance performances are entirely different in both magnitude and speed of sway (spatial, temporal). According to Wu, McKay and Angulo-Barroso (2009), and also Khasawneh (2015), continual refinement of postural control can be observed apparently up to adolescence. Moreover, balance training exercises decrease lower-limb strength asymmetry in young tennis players (Sannicandro, Cofano, Rosa, & Piccinno, 2014).

Using a force platform to evaluate static balance control is usual in a testing room environment (Hrysomallis, 2007; Mancini et al., 2012), but not outdoor. Such measurements have been considered until recently a "reference standard" (Huurnink, Fransz, Kingma, & van Dieen, 2013) for static balance, as the method captures even subtle changes that otherwise are quite difficult to quantify.

The force platform provides researchers and clinicians with a "fingerprint" capable of predicting injuries and accidents (McGuine, Greene, Best, & Leverson, 2000; McKeon & Hertel, 2008). However, these platforms are often costly, often need advanced knowledge to be operated and are difficult to transport. A sub-study with 57 participants (Malliou et al., 2010) randomly selected from a broader study (entitled "The Childhood Health Activity and Motor Performance School Study Denmark", performed between August 2008 and July 2014 on 1300 participants from 10 public schools) proposed an alternative to the indoor laboratory equipment, the Nintendo Wii Board(®).

https://dx.doi.org/10.15405/epsbs.2019.02.91
Corresponding Author: Rodica Prodan
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

In the sub-study mentioned above, Bland-Altman plots with 95% limits of agreement (LOA) were computed to quantify reproducibility of the measurement devices and the concurrent validity (Bland & Altman, 1995). By using them, the plots should be centred on the line of zero difference. Further, this type of plots indicates systematic differences (Bland & Altman, 2003). To quantitatively describe the intra-subject variability between sessions, the standard error of measurement (SEM) and the minimum detectable change (MDC) were computed. MDC defines the limits within a change in the measurement score that could be attributed to measurement error. SEM was computed as the standard deviation (SD) of the mean differences between test and retest divided by $\sqrt{2}$. MDC is closely related to SEM, as MDC is computed as $1.96*\sqrt{2}*SEM$ (Stratford, 2004). MDC is also related to the bounds of agreement. As a real shift in measure, it is only statistically meaningful and not due to measurement error, if the change in measure is outside the 95% LOA (de Vet, Terwee, Mokkink, & Knol, 2011).

Also, it was obtained a high accuracy rate in the Centre of Pressure path Length measurements, compared to the indoor laboratory equipment. The percentage difference in the mean value was computed as MDC/COPL mean *100.

Coefficients of reproducibility and concurrent validity were appraised by the concordance correlation coefficient (CCC).

All the above-listed measurements and computations, interlaced with plots by the authors of that sub-study (Malliou et al., 2010), form a solid background underpinning the validation of the Nintendo Wii Board(®), as “recognized” measurement equipment for balance investigation.

5.2. Knee-peak isokinetic moment measurements

Measurements of peak isokinetic moment in the knee flexors and extensors were performed the next day after balance evaluation to quantify the amount of muscle fatigue produced by the tennis training session. The participants were secured with straps in the seated position on the chair of an isokinetic dynamometer, at a hip joint angle of 110 degrees, with the dynamometer lever and knee joint axes being visually aligned. After a classical warm-up, three successive rounds of maximal effort knee extension-flexion contractions were performed at two different angular velocities, first at 60 degrees per second and then at 180 degrees per second. More than one angular velocity was examined to check whether the tennis training session would affect the production of muscular strength similarly in slower and faster contractions. The two tests were performed 1 minute apart, and the two legs were tested 3 minutes apart. Visual feedback of the recorded joint moment values was provided. For each angular velocity, muscle group and leg, the contraction with the highest peak moment value was considered for further analysis.

5.3. Statistical analysis

To test the differences in individual balance and isokinetic performance between pre and post tennis training sessions, a one-way repeated-measurements analysis of variance was done. The statistical significance level was set at $p \leq 0.05$.

https://dx.doi.org/10.15405/epsbs.2019.02.91
Corresponding Author: Rodica Prodan
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

6. Findings

The primary result used for the investigation of reproducibility and simultaneous validity was the median of the three COPL measurements from two successful trials in every of the four performed tests. The median was preferred as it was used in a similar study (Clark et al., 2010), but also to get rid of possible exceptions. Histograms and quantile-quantile plots were made to investigate the premises of COPL data normal distribution and differences in COPL.

Bland-Altman plots of the average COPL established no organized bias. The line of the observed agreement was roughly similar to the line of perfect agreement. In the standing test for the dominant leg, the range of LOA was most substantial.

The CCC was ≥ 0.80, ranging from 0.82 to 0.93. The MDC (26.5-28.6% of the mean COPL) ranged between 16.9 and 36.9 cm. The mean COPL disparity was most significant for the non-dominant one-leg standing test.

The isokinetic torque measurements after tennis training were lower ($p < 0.05$) than before tennis training, indicating that the tennis training inflicted muscle fatigue. The average torque reduction for the knee extensors and flexors ranged from 7 to 12% (Table 01).

Table 01. Knee-joint isokinetic moment measurements. *

Type of measurement	**Pre-training Mean ± SD**	**Post-training Mean ± SD**
Right knee extensors at 60º·s^{-1} (N·m)	176±23	154±15
Right knee extensors at 180º·s^{-1} (N·m)	109±38	94±33
Left knee extensors at 60º·s^{-1} (N·m)	174±12	154±20
Left knee extensors at 180º·s^{-1} (N·m)	110±24	94±16
Right knee flexors at 60º·s^{-1} (N·m)	102±17	95±21
Right knee flexors at 180º·s^{-1} (N·m)	73±18	66±32
Left knee flexors at 60º·s^{-1} (N·m)	96±24	86±19
Left knee flexors at 180º·s^{-1} (N·m)	69±18	57±17

*Data are presented as mean and SD, n = 24.

The ANOVAs with repeated measures showed no difference ($p > 0.05$) in individual balance performance between the measured pre and post training values.

Moreover, it was not observed any influence of the tennis training class on any of the measured parameters: for the standing only on the dominant leg $F(1.23) = 0.982$, $p > 0.05$; for the standing only on non-dominant leg $F(1.23) = 0.843$, $p > 0.05$; for the standing on both legs with eyes open $F(1.23) = 1.023$, $p > 0.05$; for the standing on both legs with eyes shut $F(1.23) = 0.975$, $p > 0.05$.

7. Conclusion

The main advantage of this study is represented by its field setting. The static balance investigation for 12 months is also one of the strengths of this study.

Specific disturbances were impossible to be avoided, due to the other kids interested in what was happening on the court during the “special classes”, but despite this, the results in terms of validity and reproducibility were decent.

https://dx.doi.org/10.15405/epsbs.2019.02.91
Corresponding Author: Rodica Prodan
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

The absence of dynamic tests is a restraint of this research. Static balance is considered to be only one component of overall balance (Shumway-Cook & Woollacott, 2007; Hrysomallis, 2007), and accordingly, the outcome in the current research cannot be postulated to resolutions of the total concept of balance.

The question regarding the optimum moment for practicing balance-specific exercises, before or after the tennis training, remains unanswered.

The evaluations were not broken down further by age and sex. Only in the test-retest inquiry, authors did some post hoc analysis broken down by grade and sex. Results showed greater CCC values in the one-leg standing tests for 14 years aged participants compared to the 10 years old ones. This fact confirms the hypothesis of age-specific differences based on shortcomings of motor control progress and diminished focus ability. Furthermore, in all four tests, results showed lower CCC measured values for boys than for girls. Nevertheless, these measured values could be biased due to a small sample size of only 24 participants; authors consider that it is an entitled call for future research to look for precise distinctions in balance conduct between genders and age groups.

The data evaluation revealed that the tennis training class did not affect the tennis players' balance ability meaningfully.

It should be recalled that the present tennis class aimed to improve the technique and tactics of the game. This could explain the present findings from the dynamometric measurements in the knee extensors and flexors, which have shown a reduction of only 7-12% in the contractile joint moment.

References

Bland, J. M., & Altman, D. G. (1995). Comparing methods of measurement: Why plotting difference against standard method is misleading. *Lancet*, *346*(8982), 1085-1087.

Bland, J. M., & Altman, D. G. (2003). Applying the right statistics: Analyses of measurement studies. *Ultrasound in Obstetrics and Gynecology*, *22*(1), 85-93.

Clark, R. A., Bryant, A. L., Pua, Y., McCrory, P., Bennell, K., & Hunt, M. (2010). Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. *Gait Posture, 31*(3), 307-310.

de Vet, H. C. W., Terwee, C. B., Mokkink, L. B., & Knol, D. L. (2011). *Measurement in medicine: A practical guide*. Cambridge: Cambridge University Press.

Groppel, J. L. (2003). *Balance critical to better tennis*. Retrieved from http://www.addvantageuspta.com/default.aspx/act/newsletter.aspx/category/ADD-askprof/MenuGroup/ADD-depts/NewsLetterID/332/startrow/50.htm

Hrysomallis, C. (2007). Relationship between balance ability, training and sports injury risk. *Sports Medicine, 37*(6), 547-556.

Huurnink, A., Fransz, D. P., Kingma, I., & van Dieen, J. H. (2013). Comparison of a laboratory grade force platform with a Nintendo Wii Balance Board on measurement of postural control in single-leg stance balance tasks. *Journal of Biomechanics, 46*(7), 1392-1395.

Khasawneh, A. (2015). Anthropometric measurements and their relation to static and dynamic balance among junior tennis players. *Sport Science, 8*(Suppl. 1), 87-91.

Malliou, V. J., Beneka, A. G., Gioftsidou, A. F., Malliou, P. K., Kallistratos E., Pafis, G. K., … Douvis, S. (2010). Young tennis players and balance performance. *Journal of Strength and Conditioning Research, 24*(2), 389-393.

Mancini, M., Salarian, A., Carlson-Kuhta, P., Zampieri, C., King, L., Chiari, L., & Horak, F. B. (2012). ISway: A sensitive, valid and reliable measure of postural control. *Journal of NeuroEngineering and Rehabilitation, 9*: 59. Retrieved from https://doi.org/10.1186/1743-0003-9-59

https://dx.doi.org/10.15405/epsbs.2019.02.91
Corresponding Author: Rodica Prodan
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

McGuine, T. A., Greene, J. J., Best, T., & Leverson, G. (2000). Balance as a predictor of ankle injuries in high school basketball players. *Clinical Journal of Sport Medicine, 10*(4), 239-244.

McKeon, P. O., & Hertel, J. (2008). Systematic review of postural control and lateral ankle instability. Part I: Can deficits be detected with instrumented testing? *Journal of Athletic Training, 43*(3), 293-304.

Sannicandro, I., Cofano, G., Rosa, R. A., & Piccinno, A. (2014). Balance training exercises decrease lower-limb strength asymmetry in young tennis players. *Journal of Sports Science & Medicine, 13*(2), 397-402.

Sherrington, G. S. (1906). *The integrative action of the nervous system*. New Heaven: Yale University Press, London: Humphrey Milford, Oxford University Press.

Shumway-Cook, A., & Woollacott, M. H. (2007). *Motor control. Translating research into clinical practice* (3rd ed.). Baltimore: Lippincott Williams & Wilkins.

Stratford, P. W. (2004). Getting more from the literature: Estimating the standard error of measurement from reliability studies**.** *Physiotherapy Canada, 56*, 27-30.

Wu, J., McKay, S., & Angulo-Barroso, R. (2009). Center of mass control and multi-segment coordination in children during quiet stance. *Experimental Brain Research, 196*(3), 329-339.