Balance Index Score as a Predictive Factor for Lower Sports Results or Anterior Cruciate Ligament Knee Injuries in Croatian Female Athletes – Preliminary Study

Schnurrer-Luke-Vrbanić, Tea; Ravlić-Gulan, Jagoda; Gulan, Gordan; Matovinović, Damir

Source / Izvornik: **Collegium antropologicum, 2007, 31, 253 - 258**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:184:309793

Coll. Antropol. **31** (2007) 1: 253–258
Original scientific paper

Balance Index Score as a Predictive Factor for Lower Sports Results or Anterior Cruciate Ligament Knee Injuries in Croatian Female Athletes – Preliminary Study

Tea Schnurrer-Luke Vrbanić[1], Jagoda Ravlić-Gulan[2], Gordan Gulan[1] and Damir Matovinović[1]

[1] Orthopaedic Clinic Lovran, Medical Faculty, University of Rijeka, Rijeka, Croatia
[2] Department of Physiology and Immunology, School of Medicine, University of Rijeka, Rijeka, Croatia

A B S T R A C T

Female athletes participating in high-risk sports suffer anterior cruciate ligament (ACL) knee injury at a 4- to 6-fold greater rate than do male athletes. ACL injuries result either from contact mechanisms or from certain unexplained non-contact mechanisms occurring during daily professional sports activities. The occurrence of non-contact injuries points to the existence of certain factors intrinsic to the knee that can lead to ACL rupture. When knee joint movement overcomes the static and the dynamic constraint systems, non-contact ACL injury may occur. Certain recent results suggest that balance and neuromuscular control play a central role in knee joint stability, protection and prevention of ACL injuries. The purpose of this study is to evaluate balance neuromuscular skills in healthy Croatian female athletes by measuring their balance index score, as well as to estimate a possible correlation between their balance index score and balance effectiveness. This study is conducted in an effort to reduce the risk of future injuries and thus prevent female athletes from withdrawing from sports prematurely. We analysed fifty-two female athletes in the high-risk sports of handball and volleyball, measuring for their static and dynamic balance index scores, using the Sport KAT 2000® testing system. This method may be used to monitor balance and coordination systems and may help to develop simpler measurements of neuromuscular control, which can be used to estimate risk predictors in athletes who withdraw from sports due to lower sports results or ruptured anterior cruciate ligament and to direct female athletes to more effective, targeted preventive interventions. The tested Croatian female athletes with lower sports results and ACL knee injury incurred after the testing were found to have a higher balance index score compared to healthy athletes. We therefore suggest that a higher balance index score can be used as an effective risk predictor for lower sports results and lesser sports motivation, anterior cruciate ligament injury and the ultimate decision to withdraw from active participation in sports. If the balance testing results prove to be effective in predicting the occurrence of ligament injuries during future sports activities, we suggest that prophylactic training programs be introduced during athlete training, since the prevention of an initial injury will be more effective than prevention of injury recurrence.

***Key words**: balance testing, predictive risk factor, ACL knee injuries, female athletes, neuromuscular control*

Introduction

Normal balance and balance during sports activities require proper neuromuscular control, which is a unique integration of inputs from the periphery into the central nervous system and back, with the aim of maintaining the posture in non-constant, external environment. This occurs unconsciously and skeletal muscles surrounding a joint are automatically activated in response to sensory stimuli[1]. If something is lacking in the neuromuscular pathway, one or more risk factors develop, predisposing athletes to injury.

In the general population, anterior cruciate ligament (ACL) knee injury is relatively uncommon[2]. ACL injuries are associated with sports activities (volleyball, handball,

Received for publication April 4, 2006

basketball) in which the vast majority of participants are adolescents and young adults (15 to 25 years of age)[3]. Furthermore, it is well documented that a female athlete is more likely to sustain ACL knee injury than a male athlete while engaged in the same activity[4–10]. An ACL injury can result either from an exterior impact on the knee or from an unexplained non-contact mechanism during sports activities athletes engage in daily. The fact that non-contact injuries occur suggests the existence of intrinsic factors that can lead to ACL rupture. When joint movement develops in the knee and overcomes the static and the dynamic constraint systems, non-contact ACL injury may occur. Some researches have suggested that subtle differences in neuromuscular function and balance control may act as causal factors[11]. Recent studies have shown that balance training, as well as teaching athletes how to jump, land, and cut in specific ways, may decrease ACL injury rate[12–14]. This suggests that balance and neuromuscular control play a crucial role in knee joint stability, protection and prevention of injuries.

The purpose of this study is to evaluate balance neuromuscular skills by measuring the balance index score in healthy Croatian female athletes, as well as balance effectiveness, in the effort to reduce future injuries and prevent female athletes from withdrawing from sports prematurely. Additional aim of this study is increasing the interest in injury prevention, by fostering educational efforts aimed to enhance awareness of this injury, as well as incorporating balance training into pre-practise warm-up routine of female athletes in the way that could be used to direct them to more effective and targeted knee-safe preventive interventions.

Subjects

Fifty-two European handball and volleyball female athletes (I/II division) participated in this study during a routine physical examination. It was performed at the Department for physical medicine, rheumatology and rehabilitation, Clinic for Orthopaedic surgery Lovran. Initially, the subjects were tested on a commercially available device used for measuring static and dynamic balance proficiency in conditions of instability artificially created by the device. The subjects examined were all physically active and without previous knee injuries.

After five years of active participation in professional sports activities, the same population was asked to respond to a closed-ended yes/no questionnaire regarding their further participation in sports and any current ACL knee injuries. Injuries were diagnosed by physical examination and arthroscopic surgical verification.

Methods

The measurements were performed by an instrumented balance assessment system (Sport KAT 2000, Berg. Inc., San Marcos, CA, USA®) which is commercially available for testing and/or balance training. Validation and calibration of this device has been reported in a previous investigation[15]. It consists of a circular platform with varying degrees of stability, centred by a small pivot. This apparatus contains a movable floor, allowing for the floor pressure to be controlled. All test studies were carried out at uniform hydraulic pressure value of 6 psi to standardize the conditions of testing for all subjects. The platform is equipped with a two-axis electrolytic tilt sensor (Accustar II, Lucas Sensing Systems, Phoenix, AZ, USA®), fixed at the anterior edge of the circular platform and it quantifies position of the transverse plane.

The objective of the static balance test was to maintain the platform at the initial level relative to the X and Y axes. The objective of the dynamic balance test was to follow a round target in a clockwise and counter-clockwise moving circle. A numerical score was given, based on the actual time spent in the exercise and the distance from the centre of the platform, measured every second. This was recorded in a detailed printout of all movements. In the printout, estimated time and distance are denoted by the Balance Index Score (BIS), which represents the combined coordinate position of all data acquired during the static and dynamic balance tests. A score is calculated by measuring the distance from the tilted position to the reference position and adding up the absolute numbers over the duration of the test. The lower the score, the better is the balance index. Static BIS above 500 was considered a poor result, as well as a result of over 1500 for dynamic BIS[15].

The testing protocol required the individual to stand barefoot on the platform with the knees slightly bent (approximately 20 degrees) without holding onto the handrail, first standing on the platform with both feet, and second standing on each leg separately. All participants underwent three familiarization exercises on the testing device, one static and two dynamic, one minute each. Once comfortable on the testing device, they performed a formal static test, which included standing in place, maintaining balance. The participants were given computer screen feedback for a period of 30 seconds for each of the exercises, one standing on both feet and one standing on each leg separately. They were then asked to complete several sequential dynamic balance tasks. First, they followed a moving circle on the computer screen, their bodies mimicking the movement of the computer screen target. This was performed first in a clockwise direction (right) and then in a counter-clockwise (left) direction, first standing on both feet and then standing on each leg separately.

Statistical analysis

The mean and standard error of the mean for each variable were calculated for each subject group. A Student's *t*-test was performed to determine significant differences between groups ($p<0.05$ was used as the cut-off value for significance). Finally, multiple regression analysis between dependent variables was performed.

Results

The mean age of the fifty-two female athletes without previous knee injuries who participated in this study was 18.4±0.5 years, while the range was 15–22 years. At the initial examination, static and dynamic balance proficiency was tested on a commercially available balance testing device, described in detail in the section Subjects and methods. All data acquired during the testing procedure were expressed as the Balance Index Score (BIS).

Five years later, the participants were interviewed about their subsequent participation in sports and their current ACL knee injuries. Based on their answers they were divided into two main groups: the first group was still active in sports (*Players*), while the second group withdrew from sports due to lower results in sports or due to a ruptured anterior cruciate ligament (*No-more-Players*).

The mean age of the *Players* was 18.1±1.9, and of *No-more-Players* 18.6±2.0, without statistically significant difference (t=0.86, p>0.05, Figure 1).

Thirty-six (69%) of all participants were still active in handball or volleyball (*Players* group). From these thirty-six, thirty-one (86%) were without injury, while five (14%) have developed ACL knee injury. In three of the five, the injury is of a non-contact character, while in two it resulted from contact of the knee with external objects. Four of the five underwent arthroscopic reconstruction of the ACL, and one still plays with an ACL-deficient knee, but in a goal-keeper position.

No-more-Players group consisted of sixteen subjects (31%). Among them, fourteen subjects (87%) indicated that they had significantly decreased their level of sports activity as a result of lower sport progress, while two of them (13%) withdrew from sports as a result of non-contact ACL knee injury, where the ligament did not undergo reconstruction.

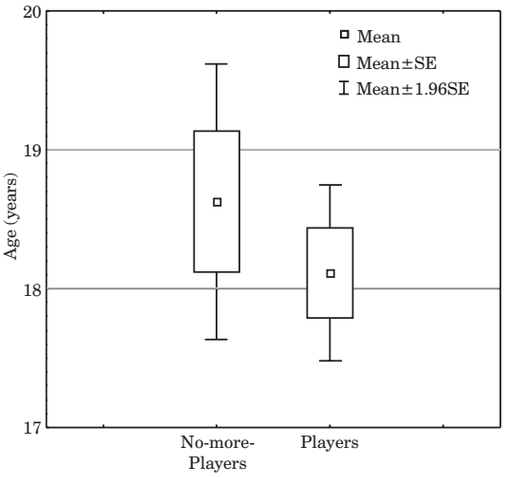

Fig. 1. The mean age in No-more-Players and Players groups (t=3.79, p< 0.05).

The study has shown that seven of the fifty-two participants (5 from *Players* group and 2 from *No-more-Players* group) developed ACL knee injury, which represents 13% of the total – a result in the range of world epidemiologic statistics[16–17].

The study has also shown that results for static and dynamic BIS were lower in *Players* than in *No-more-Players*, with a statistically significant difference (p< 0.05, Figure 2).

It was noticed that female athletes with a higher BIS rate withdraw from sports or sustain ACL injuries more often than their co-players with a lower BIS in all values measured together (Table 1), suggesting a trend based on the BIS rate. Multiple linear regression analysis for the dependent variable between balance index score and further participation in sports yielded a result of R=0.12,

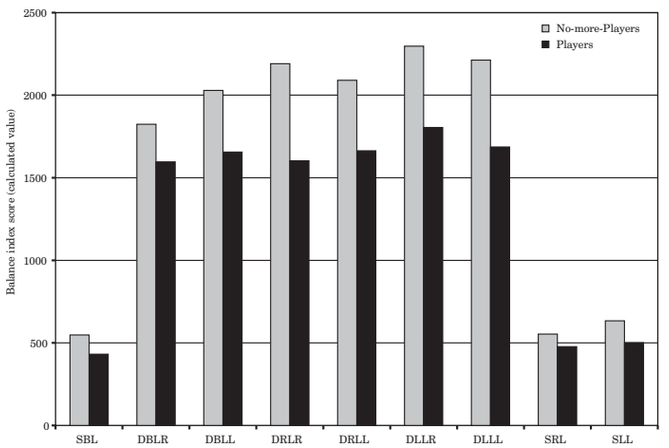

Fig. 2. Static and dynamic balance index score (BIS) for No- -more-Players and Players groups. SBL – static test on both legs, DBLR – dynamic test on both legs – right direction, DBLL – dynamic test on both legs – left direction, DRLR – dynamic test on right leg – right direction, DRLR – dynamic test on right leg – right direction, DRLL – dynamic test on right leg – left direction, DLLR – dynamic test on left leg – right direction, DLLL – dynamic test on left leg – left direction, SRL – static test on right leg, SLL – static test on left leg.

TABLE 1
MULTIPLE LINEAR REGRESSION ANALYSIS FOR THE DEPENDENT VARIABLE BETWEEN BALANCE INDEX SCORE (BIS) AND FURTHER PARTICIPATION IN SPORTS

N=52	R=0.61196457, R^2=0.37450064, Adjusted R^2=0.24046506 F(9.42)=2.7940, p<0.01158, Std.Error of estimate: 0.40616					
	Beta	Std.Err. of Beta	B	Std.Err. of B	t (42)	p-level
Intercept			112.6414	0.294536	382.4365	0.000000
SBL	–0.310996	0.160866	–0.0010	0.000525	–1.9333	0.059963
DBLR	0.231260	0.208020	0.0003	0.000226	1.1117	0.272581
DBLL	–0.232968	0.193328	–0.0002	0.000157	–1.2050	0.234936
DRLR	–0.695497	0.360766	–0.0006	0.000316	–1.9278	0.060656
DRLL	–0.197580	0.240076	–0.0002	0.000232	–0.8230	0.415164
DLLR	0.076209	0.255403	0.0001	0.000190	0.2984	0.766878
DLLL	0.249720	0.311047	0.0002	0.000237	0.8028	0.426590
SRL	0.220627	0.219727	0.0007	0.000676	1.0041	0.321082
SLL	0.054194	0.207134	0.0001	0.000465	0.2616	0.794878

SBL – static test on both legs, DBLR – dynamic test on both legs – right direction, DBLL – dynamic test on both legs – left direction, DRLR – dynamic test on right leg – right direction, DRLL – dynamic test on right leg – left direction, DLLR – dynamic test on left leg – right direction, DLLL – dynamic test on left leg – left direction, SRL – static test on right leg, SLL – static test on left leg

which was statistically significant (F=2.79, p<0.05), con- firming the existence of a trend to withdraw from sports or sustain ACL injury based on the BIS rate.

Discussion

It has been long recognized that ACL injuries are not only acutely problematic because of the functional joint instability they cause, but also because they are the source of several long term concerns[18]. The association of posttraumatic degenerative joint disease with both ACL injuries and the often accompanying menisceal injuries is well known[19]. Therefore, the high incidence of ACL injuries in 15 to 22-year old female athletes and the significant physical, psychological and financial implications of this injury point to the significance of estimating risk factors predisposing athletes to injury and to the importance of developing successful preventive programs.

Under physiological conditions, stability of the knee is maintained by the neuromuscular system and the feedback mechanisms operating among ligament structures, muscle activity and joint surface contact forces, which are continuously required for maintaining balance and posture in the external environment. Forces activated at the joint during physical activity are often beyond the capacity of the passive ligamentous constraints, thus requiring the addition of active muscular forces to maintain joint equilibrium and stability[20]. When dynamic stability is inadequate or slow to develop, significant strain is placed on the passive restraints of the knee and injuries may occur[21–28]. Furthermore, the lack of balance and coordination skills may be a reason for lesser sports motivation, lower sports results and ultimately withdrawing from sports.

Using Sport KAT® diagnostic methodology, described above, we were able to diagnose a critical balance dysfunction in female athletes who, five years after the initial examination were still active in sports. Several of them developed non-contact ACL knee injury. This injury forced some of them to end their participation in the current sports season or even end their career, at times requiring costly surgery and rehabilitation. We found that their test scores were actually higher for all static and dynamic variables compared to the *Players* group. One possible explanation for these higher scores is that athletes who scored higher shifted their centre of gravity farther than the task given to them demanded, by also employing compensatory muscle groups from other joints within the kinetic chain to control their balance. Therefore, their neuromuscular system did not perform optimally and proper muscle contraction did not occur at appropriate times. This is most probably due to the fact that at various stages of maturation of athletes' motor skills, the forces transmitted to the body differ due to the development of athletes' size and strength and the changing nature of sports activity during the sports season, as well as due to the increased competitiveness of sports activity. Given that neuromuscular control is related to the conditioning of the athlete, it is potentially modifiable and includes coordination of movement recruitment patterns[29]. Therefore, the main goal of balance as such is not to achieve a powerful isolated muscle contraction in a given amount of time, but to shorten the period of time required for the mental reaction and physical movement to accomplish a task.

While the mean age of the *No-more-Players* group was significantly higher than that of the *Players* group, it is nevertheless not the expected age for withdrawing from sports. During our interview, the *No-more-Players* em-

phasised that their main reason for withdrawing from sports was the failure to achieve the desired results.

The absence of effective neuromuscular control in maintaining balance and posture may be responsible for increased rates of non-contact knee injury in female athletes and, consequently, for their unsatisfactory results. However, this method is not normally used during preparatory and competitive period in Croatian healthy athletes.

Chandy et al.[30] and Hewett et al.[31] have suggested that assessing the risk of potential injury prior to engaging in sports, followed by timely intervention where necessary, may decrease the relative injury incidence in athletes. Screening of athletes prior to engaging in sports (pre-participation screening) is crucial for identifying those with inefficient coordination and predisposition to knee injury who would benefit from a training programme designed to enhance their strength and neuromuscular stability, especially of the knee joint. If such methods are developed, screening could be evaluated also in other sports and those who would benefit from training could be easily identified. Thus, knowledge gained from this type of research could have a major impact on how athletes are tested and trained prior to engaging in sports.

In order to prevent injuries, it is necessary that the central nervous system and the passive and active restraint systems interact optimally, because strong and flexible muscles must be engaged at appropriate times. Therefore, it is necessary to test and train the balance and neuromuscular systems timely.

Hence, understanding the importance of BIS results will lead to more effective prevention strategies for female athletes currently suffering from balance dis-coordination.

Pre-participation balance screening is crucial for identifying those athletes predisposed to knee injury and dis--coordination who would benefit from training programmes designed to enhance neuromuscular stability of the knee joint. Even a slight decrease of an elevated BIS score may have a significant effect on preventing knee injury, which is a prerequisite for prolonged sports participation.

During five years of active sports participation in I/II division seven athletes suffered ACL rupture; two developed a contact ACL knee injury, which is not possible to prevent by the methods we suggested for non-contact ACL injuries. In fact, these two athletes had achieved BIS scores equal to those of healthy athletes, while the five athletes with non-contact ACL injury had significantly higher BIS scores compared to healthy athletes. Four of the injured athletes underwent ACL reconstruction and resumed their participation in sports. One of them did not undergo surgical treatment following the injury and is still active in handball, however, only as a goal-keeper. However, two athletes with non-contact injury were forced to end their intended sports career.

If the balance testing results prove to be efficient in predicting the occurrence of ligament injuries during professional sports activities, prophylactic training programmes should be introduced as part of the athletes' training, since prevention of an initial injury will be more effective than prevention of injury recurrence.

Results demonstrate double the injury rate in female athletes with high BIS scores. However, if athletes were able to anticipate an injury (consciously or subconsciously) the coordinated muscular response could be set in motion prior to the onset of the injury. As a result, preparatory actions could be taken to reduce the impact of the impending injury. The feed-forward mechanisms in the neuromuscular control system may enable such prevention strategies to be employed. Yet, unless the warning occurs well in advance of the injury, the latencies associated with the motor response would nevertheless render sports injury prevention unlikely. In theory, the likelihood of injury prevention could be improved by the presence of pre-programmed movement strategies that could be triggered when receptors detect an impending injury. Although the idea of pre-programmed reactions has been discussed in the joint stability literature, research has yet to substantiate the claim that such mechanisms contribute to dynamic knee stability[32–34]. In our opinion, the described balance tests are specifically directed at training athletes to reduce the load on their knee ligaments by exercising better control of their centre of gravity by producing better coordinated and more consistent movement patterns. By developing motor programs that are characterized by coordinated muscle activity and by training athletes to perform skills in a more bio-mechanically safe fashion, it is likely that we can reduce the incidence of serious knee ligament injuries to a certain degree. Continued research in this area is therefore of great importance.

Conclusion

Female athletes with high BIS levels have compromised balance and neuromuscular control and are therefore at a high risk of ACL injury. Modern techniques of balance diagnosis and therapy allow us to identify and therapeutically aid such athletes. Incorporating balance training exercises, such as balance board exercises, into pre-season and in-season conditioning programs for such athletes could improve their sports skills and decrease their risk of sustaining knee injuries.

REFERENCES

1. MATTHEWS PB, Annu Rev Neurosci, 5 (1982) 189. — 2. FRANK CB, JACKSON DW, J Bone Joint Surg Am, 75 (1997) 1556. — 3. ARENDT E, DICK R, Am J Sports Med, 23 (1995) 694. — 4. ZILLMER DA, POWELL JW, ALBRIGHT JP, J Womens Health, 1 (1992) 69. — 5. WHITESIDES PA, Phys Sportsmed, 8 (1980) 130. — 6. ZELISKO JA, NOBLE HB, PORTER M, Am J Sports Med, 10 (1982) 297. — 7. CHANDY TA, GRANA WA, Phys Sportsmed, 13 (1985) 106. — 8. FERRETTI A, PAPANDREA P, CONTEDUCA F, MARIENI PP, Am J Sports Med, 20 (1992) 203. — 9. LINDENFELD TN, SCHMITT DJ, HENDY MP, MANGINE RE, NOYES FR, Am J Sports Med, 22 (1994) 364. — 10. MYKLE-

BUST G, MAEHLUM S, HOLM I, BAHR R, Scand J Med Sci Sports, 8 (1998) 149. — 11. HUSTON LJ, WOYTIS EM, Am J Sports Med, 24 (1996) 427. — 12. CARAFFA A, CERULLI G, PROJETTI M, AISA G, RIZZO A, Knee Surg Sports Traumatol Arthrosc, 4 (1996) 19. — 13. HEWETT TE, LINDENFELD TN, VRICCOBENE J, NOYES FR, Am J Sports Med, 27 (1999) 27. — 14. BARATTA R, SOLOMONOV M, ZHOU B H, LESTON D, CHUINERD R, D'AMBROSIA R, Am J Sports Med, 16 (1988) 113. — 15. JOHNSTON RB, HOWARD ME, CAWLEY PW, LOOSE GM, Med Sci Sports Exerc, 30 (1998) 1703. — 16. MAJEWSKI M, SUSANNE H, KLAUS S, Knee, 13 (2006) 184. — 17. RECKLING C, ZANTOP T, PETERSEN W, Sportverletz Sportschaden, 17 (2003) 112. — 18. HERTEL P, BEHREND H, CIERPINSKI T, MUSAHL V, WIDJAJA G, Knee Surg Sports Traumatol Arthrosc, 13 (2005) 248. — 19. ENGLUND M, LOHMANDER LS, Ann Rheum Dis, 64 (2005) 1721. — 20. SOLOMONOW M, BARATTA R, ZHOU BH, Am J Sports Med, 15 (1987) 207. — 21. CASTRO MJ, MCCANN DJ, SHAFFRATH JD, ADAMS WC, Med Sci Sports Exerc, 27 (1995) 397. — 22. HAKKINEN K, KOMI PV, Int J Sports Med, 4 (1983) 282. — 23. BARRACK RL, LUND PH, SKINNER HB, J Rehabil, 3 (1994) 18. — 24. SMALL C, WATERS JT, VOIGHT M, J Orthop Sports Phys Ther, 19 (1994) 335. — 25. WOJTYS EM, HUSTON LJ, Am J Sports Med, 22 (1994) 89. — 26. ROZZI SL, LEPHART SM, FU FH, J Athl Train, 34 (1999.) 106. — 27. WOYTIS EM, WYLIE BB, HUSTON LJ, Am J Sports Med, 24 (1996) 615. — 28. O'CONNOR JJ, J Bone Joint Surg Br, 75 (1993) 41. — 29. LEPHART SM., ABT JP, FERRIS CM, Curr Opin Rheumatol, 14 (2002) 168. — 30. CHANDY TA, GRANA WA, Sports Med, 13 (1985) 106. — 31. HEWETT TE, Sports Med, 29 (2000) 313. — 32. WILLIAMS GN, CHMIELEWSKI T, RUDOLPH KS, BUCHANAN TS, SNYDER-MACKLER L, J Orthop Sports Phys Ther, 31 (2001) 546. — 33. TYLER TF, MCHUGH MP, J Orthop Sports Phys Ther, 31 (2001) 577. — 34. HEWETT TE, MYER GD, FORD KR, HEIDT RS, COLOSIMO AJ, MCLEAN SG, VAN DEN BOGERT AJ, PATERNO MV, SUCCOP P, Am J Sports Med, 33 (2005) 492.

T. Schnurrer Luke Vrbanić

Department for physical medicine, rheumatology and rehabilitation, Clinic for orthopaedic surgery Lovran, Medical Faculty, University of Rijeka, M. Tita 1, 51415 Lovran, Croatia
e-mail: tlukevrb@inet.hr

RAVNOTEŽNI INDEX KAO PREDIKTIVNI ČIMBENIK LOŠIH SPORTSKIH REZULTATA ILI OZLJEDA PREDNJEG KRIŽNOG LIGAMENTA KOLJENA U HRVATSKIH SPORTAŠICA – PRELIMINARNA STUDIJA

S A Ž E T A K

Incidencija ozljeda prednjeg križnog ligamenta (PKL) koljena u sportašica je 4–6 puta veća nego u sportaša. Mehanizam nastajanja ozljeda PKL koljena može biti kontaktni ili nekontaktni tijekom izvođenja svakodnevnih sportskih aktivnosti. Postojanje nekontaktnog mehanizma ozljede upozorava nas na razne unutarnje čimbenike koji dovode do puknuća PKL. Nekontaktna ozljeda PKL koljena nastaje kada kretnja u zglobu koljena nadilazi statičke i dinamičke stabilizatore. Rezultati brojnih istraživanja pokazuju da ravnoteža i živčano-mišićna kontrola igraju središnju ulogu u stabilnosti koljena, zaštiti i prevenciji ozljeda PKL. Cilj ove studije je evaluacija ravnoteže i živčano-mišićnih vještina u zdravih hrvatskih sportašica mjerenjem ravnotežnog indeksa kao i dokazivanje korelacije između ravnotežnog indeksa i učinkovitosti ravnoteže u spriječavanju ozljede. Daljnji cilj ove studije je smanjiti rizik budućih ozljeda i prevenirati prerano odustajanje od bavljenja sportom. Mjerili smo statički i dinamički ravnotežni indeks pomoću aparata Sport KAT 2000® u pedeset i dvije rukometašice i odbojkašice. Ovom metodom može se evaluirati ravnoteža i koordinacija te stupanj živčano-mišićne kontrole, što se može iskoristiti u određivanju prediktivnih čimbenika rizika u daljnjem bavljenju sportom. Ciljnim preventivnim djelovanjem spriječava se prerano odustajanje od aktivnog bavljenja sportom zbog loših rezultata ili zbog ozljeda PKL koljena. Sportašice koje su imale lošije sportske rezultate ili su zadobile ozljedu PKL koljena imale su veće vrijednosti ravnotežnog indeksa u usporedbi sa zdravom kontrolom. Pretpostavlja se da se više vrijednosti ravnotežnog indeksa mogu koristiti kao prediktivni čimbenik rizika preranog odustajanja od sporta zbog lošijih sportskih rezultata, slabije sportske motivacije ili ozljeda PKL. Ukoliko rezultati testiranja ravnoteže mogu predvidjeti povećan rizik u nastajanju ozljede PKL tijekom sportskih aktivnosti, preporuka je profilaktičko uključivanje vježbi održavanja ravnoteže na nestabilnim podlogama u trenažnom postupku, jer bi prevencija prve ozljede svakako bila puno učinkovitija od prevencije ponovne ozljede.