African Journal for Physical, Health Education, Recreation and Dance (AJPHERD) Volume 21(1:1), March 2015, pp. 92-102.

Injury prevalence, stability and balance among female adolescent soccer players

J.P. KOENIG AND T. PUCKREE

Faculty of Health Sciences, Durban University of Technology, Durban, South Africa.
E-mail: puckreet@dut.ac.za

(Received: 07 September 2014 ;Revision accepted: 26 November 2014)

Abstract

Poor balance is a risk factor for injury in adolescent sport including soccer. There has been a rapid growth in female adolescent soccer especially in South Africa, yet the association between balance and injury in this population has not been fully explored. This study determined the relationship between static balance as measured by the Sway Index (SI), dynamic balance as measured by Limits of Stability Direction Control (LOS) and injury. Injury prevalence and the relationship between body mass index (BMI) and static/dynamic balance were also determined. Eighty adolescent female soccer players, between the ages of 14-18 years were recruited through convenience sampling from schools in the eThekwini district of KwaZulu-Natal. Height, weight, Sway Index (SI) and Limits of Stability Direction Control (LOS) readings were measured using a stadiometer, electronic scale and Biodex Biosway Portable Balance System (Biodex Medical Systems Inc., Shirley, New York) respectively. Only 27.5% of the participants sustained one or more injuries when playing soccer. The OR suggests that an injured player with poor SI is 1.44 times more likely to be injured than one with good SI. Significant correlations ($p \leq 0.05$) between BMI and SI were noted. This study revealed that poor static and dynamic balance is associated with injury in adolescent female soccer players.

Key words: Injury, sway index, balance, female soccer.

How to cite this article:
Koenig, J.P. & Puckree, T. (2015). Injury prevalence, stability and balance among female adolescent soccer players. *African Journal for Physical, Health Education, Recreation and Dance*, 21(1:1), 81-91.

Introduction

Soccer has gained popularity among female high school learners in South Africa and grown significantly with more learners participating in the sport (Mtshali, Mbambo-Kekana, Stewart & Musenge, 2009). The South African Department of Sports and Recreation (2005), has reported that 38.9% of female learners are motivated to play soccer at high school if soccer forms part of the sporting curricula. The positive growth in female soccer is associated with a high incidence of injuries worldwide (Faude, Junge, Kindermann & Dvoraket, 2005; Emery, Meeuwisse & Hartmann, 2005; Mtshali et al., 2009). The incidence of knee injury is 3-5 times higher amongst women than men (Bahr & Holme, 2003; Faude et al., 2005; Mtshali et al., 2009).

Injuries in female soccer players have been linked to a variety of intrinsic and extrinsic risk factors (Bahr & Holme, 2003; Emery et al., 2005). These factors are either non-modifiable or potentially modifiable. Few epidemiological studies have addressed modifiable risk factors for injury in adolescent sport (Emery et al., 2005). Potentially modifiable extrinsic risk factors include sports rules, playing time, playing surface, and equipment. Potentially modifiable intrinsic risk factors include fitness level, training, flexibility, strength, joint stability, biomechanics, balance and proprioception (Emery et al., 2005). The relationship between balance and injury in female soccer players is receiving attention (Steffen et al., 2013; Jaussen, 2012; Hrysomallis, 2007). Poor balance has been associated with increased injury risk among athletes (McLeod, Armstrong, Miller & Sauers, 2009).

The maintenance of posture and balance requires the integration of the visual, vestibular and somatosensory systems. Individuals rely primarily on proprioceptive and cutaneous input to maintain static balance to perform activities of daily living (Shaffer & Harrison, 2007). Choy, Brauer and Nitz (2003) showed that women aged 40-80 years relied more on vision for postural stability. Guerraz and Day (2008) believe that the visual and vestibular channels are recognized to be responsible for compensatory action and are usually considered to occur automatically and at a low level. Gaerlan (2010) showed that the visual system is predominant in maintaining posture and balance in women in the second and third decades of life. However, balance training enhanced the role of the proprioceptive system and may reduce the risk of injury in sport (Mandelbaum et al., 2009).

The Biosway unit measures the participant's postural control, postural stability as well as their sway angle and direction from the centre of gravity (Biosway Portable Balance System Operation Manual, Biodex Medical Systems Inc., Shirley, New York). The Biodex Biosway unit provides valuable objective assessment of somatosensory input and neuromuscular control which is vital to balance, thus the potential for future balance-related injury may be ascertained. Furthermore, as previously mentioned, balance involves the integration of proprioceptive, vestibular, and visual information (Gaerlan, 2010), and injury or damage to any of the structures that form these systems will result in poor balance and can possibly lead to injury, re-injury or further trauma.

Due to the paucity of studies that relate injury incidence and prevalence to static and dynamic balance, there is a need to investigate this relationship. The need to determine this relationship is especially important in adolescents and females due to the structural and physiological peculiarities in this specific population. The aim of this study was to determine the relationship between injury, BMI and static and dynamic balance in female adolescent soccer players.

Methodology

A cross sectional survey with measurements was undertaken. This study was conducted in the eThekwini district of KwaZulu Natal. To arrive at the population of soccer playing girls who met the inclusion criteria, multi-stage sampling was used. The population of schools that offer soccer to female learners in the two sub-districts namely, Pinetown and Umlazi in the eThekwini district was identified. From each district one circuit namely Umhlathuze circuit (City of Durban) from the Pinetown sub-district and Durban Central circuit from the Umlazi sub-district were conveniently chosen for participation. Convenience sampling was used to allow accessibility of the schools in the two circuits.

To be included for participation, schools had to be secondary and public. Half of the eThekwini district population of high schools which offer soccer to females were randomly sampled. In this study, three schools represented the Umhlathuze circuit (City of Durban) from the Pinetown sub-district, and four schools represented the Central Durban circuit from the Umlazi sub-district. Four of the schools used in this study were co-educational and three of the schools were for girls only. Eighty female soccer players from the initial 200 learners who met the inclusion criteria from seven selected schools were included for participation in the balance study. Statgraphics Centurion was used to determine the sample size for the study based on a population of 200. At a 95% level of confidence with a desired tolerance of 0.20, the required sample size was 80. To meet the sample size of 80 as per the initial design, female soccer players from seven schools were invited.

Inclusion and exclusion criteria

To be included girls had to be between 14-19 years of age, played soccer in the previous season, have parents/guardians signed informed consent and signed the assent form if necessary. Learners who were pregnant had any form of systemic, neurological, vestibular, or vascular disease suffered from vertigo or had benign positional vertigo recently had surgery or suffered from severe trauma excluded from the study.

Instrumentation

All participants' demographic as well as injury data was collected using a validated questionnaire. The balance variables including stability index (SI) and limits of stability (LOS) were measured using a portable Biosway unit. The BMI of each participant was calculated from the measurements of weight and height using a calibrated Safeway electronic bathroom scale and a stadiometer, respectively.

The Biosway unit was used to measure the participant's postural control. The stability index is the average position of the individual from their centre of gravity. The stability index does not indicate how much the participant swayed; it only measures their position (Biosway Portable Balance System Operation Manual, Biodex Medical Systems Inc., Shirley, New York). In order to determine the degree of sway, one measures the standard deviation of the stability index which is called the Sway Index. Data from the Modified Clinical Test of Sensory Integration and Balance (MCTSIB) and the Limits of Stability (LOS) for standing balance test was recorded and stored for analysis.

During the MCTSIB test, the sway index of each participant was measured. The higher the sway index score, the more unstable the participant is. The LOS test determines which direction a participant may have trouble controlling their limit of stability representing dynamic balance. Higher LOS scores represented good neuromuscular control while lower scores represented poor neuromuscular control.

Procedure

The study was approved by the Institutional Research Ethics Committee. After a full explanation of the procedure, the balance assessment programme commenced with each participant standing in the anatomical position, with feet flat on the platform for the duration of the assessment. Cachupe, Shifflett, Kahanov and Wughalter (2001) provided evidence that the Biodex Biosway system provides reliable and consistent results. Hinman (2000) showed that the test-retest reliability of the stability indices produced by the Biodex Biosway system is comparable to other balance measures and is acceptable for clinical testing.

For the LOS test, each participant stood on the Biosway platform and was challenged to move through a movement pattern consistent with the sway envelope. The sway envelope refers to that area a person can move their centre of gravity within their base of support. The participant was instructed to move a cursor from the centre of the screen towards blinking targets 10 degrees from the centre of the screen with their feet fixed and by moving their torso in a number of directions and thus shifting their weight (Biosway Portable Balance System Operation Manual, Biodex Medical Systems Inc., Shirley, New York).

For the MCTSIB test the participant first stood on the Biosway unit for 30 seconds with eyes open followed by a period of 30 seconds with eyes closed. This eliminated visual input, to only evaluate vestibular and somatosensory inputs (Biosway Portable Balance System Operation Manual, Biodex Medical Systems Inc., Shirley, New York). Recordings were taken and stored on the biosway database. A foam (dynamic surface) was then placed on the biosway platform, on which the participant stood for the next part of the test (30 seconds each part). Data was collected with the eyes open to assess somatosensory interaction with visual input (Biosway Portable Balance System Operation Manual, Biodex Medical Systems Inc., Shirley, New York) and the eyes closed to assess somatosensory interaction with vestibular input (Biosway Portable Balance System Operation Manual, Biodex Medical Systems Inc., Shirley, New York). Recordings were again stored.

Calculations and processing of data

The "sway index" score of the participant was calculated following the MCTSIB test and ranked on a scale of low to high scores.

Statistical analysis

All readings obtained from the Biodex Biosway Portable Balance System were captured on an SPSS spreadsheet, analysed using the statistical software SPSS version 21.0. Descriptive statistics, independent samples t tests, Mantel-Haenszel Common Odds Ratio Estimates and Pearsons correlations coefficients were applied for data analysis at a significance level of 0.05.

Results

Of the 80 participants, 12 participants (15%) were eliminated from the study due to non-compliance leaving a total of 68 respondents (85%). The original sample was made up through the recruitment of an additional 12 participants who met the inclusion and exclusion criteria, bringing the final participation rate to 100%.

The age of participants ranged from 14 to 18 years (mean ±SD = 15.7 ± 1.2 years). Participants represented Black, White, Coloured and Indian race groups. More than half (57.5%) of the participants were Black and a quarter were White.

Body Mass Index (BMI)

Approximately 67.5% of the participants were of normal weight as they were within the 18.5 – 24.99 range. More than one fifth of the participants were overweight making up 22% of the uninjured and 23% of the injured groups. Injured and uninjured group mean and standard deviations were 23.54±3.56 and 23.00±4.63, respectively.

Injury Prevalence

Only 27.5 % of the participants sustained one or more injuries when playing soccer. The majority of those who sustained injuries reported just one injury (16%).

Static Balance

Static balance was determined by sway index value (SI). The static balance of each participant was calculated during the four assessments of the SI in the Modified Clinical Test for Sensory Integration and Balance (MCTSIB). These four assessments involved each participant standing on a firm surface with eyes open, standing on a firm surface with eyes closed, standing on a foam surface with eyes open and standing on a foam surface with eyes closed.

Figure 1 shows no significant differences between the means of the injured and uninjured participants under each of the different conditions and with the goal. For SI, mean values below the goal suggest good balance. For conditions with eyes closed SI in both injured and uninjured groups suggest good static balance.
The risk estimate for injury is shown in the odds ratio in Table 1. An injured participant with poor SI EOSS is 1.44 times more likely to be injured than an injured participant with good SI in the same condition. Furthermore, an uninjured participant with poor SI EOSS is faces the same risk for injury as an uninjured participant with good SI in the same condition.

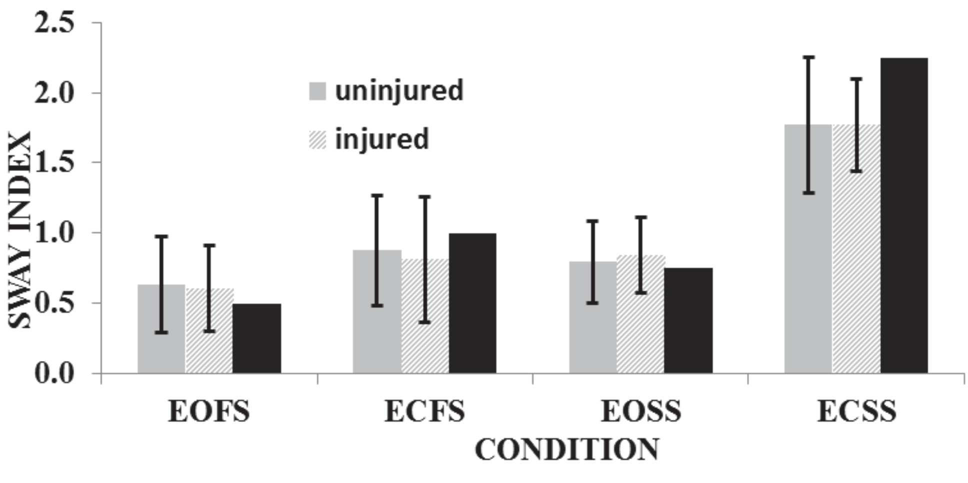

Figure 1: Mean and standard deviation for Sway Index under each of the conditions for injured and uninjured participants (**EOFS:** Eyes open firm surface**; EOFS:** eyes open firm surface**; ECSS:** eyes open soft surface**; ECSS:** eyes closed soft surface, Goal for each condition included in green)

Odds ratios for EOSS reflecting impaired proprioception poses a greater risk for injury than ECSS which reflects a combination of impaired proprioception and vision. For the EOFS where all senses are intact, the OR reflects reduced risk for injury but greater than that for ECFS in which vision is removed from the balance equation. The wide CI suggests lack of precision the OR.

Table 1: Number (%) of participants in injured and uninjured groups with good and poor SI scores and respective

SI: EOFS				OR	CI	p-value
Static Balance	Uninjured	Injured	Total			
	No.(%)	No.(%)	No.(%)			
Good	23 (28.8)	10 (12.5)	33 (41.25)	0.7886	0,2929-2.1233	0.638
Poor	35 (43.8)	12 (15)	47 (58.75)			
Total	58 (72.5)	22 (27.5)	80 (100)			
SI: ECFS						
Static Balance	Uninjured	Injured	Total			
	No.(%)	No.(%)	No.(%)			
Good	42 (52.5)	20 (25)	62 (77.5)	0.2625	0.055-1.2535	0.094
Poor	16 (20)	2 (2.5)	18 (22.5)			
Total	58 (72.5)	22 (27.5)	80 (100)			
SI: EOSS						
Static Balance	Uninjured	Injured	Total			
	No.(%)	No.(%)	No.(%)			
Good	29 (36.25)	9 (11.25)	38 (47.5)	1.4444	0.5348-3.9015	0.468
Poor	29 (36.25)	13 (16.25)	42 (52.5)			
Total	58 (72.5)	22 (27.5)	80 (100)			
SI: ECSS						
Static Balance	Uninjured	Injured	Total			
	No.(%)	No.(%)	No.(%)			
Good	49 (61.25)	19 (23.75)	68 (85)	0.8596	0.2099-3.52	0.833
Poor	9 (11.25)	3 (3.75)	12 (15)			
Total	58 (72.5)	22 (27.5)	80 (100)			

Mantel-Haenszel Common Odds Ratio Estimate (OR), Confidence Intervals (CI) and p values.

Limits of stability

There was no significant difference between the injured and uninjured groups. Dynamic balance in backward was good for both groups with the uninjured group scoring higher than the injured group (Table 2).

Table 2: Mean and standard deviation percentage control in each direction for injured and uninjured groups and desired goal.

Directions	Goal	Injured	Uninjured	p-value
overall	>65	43.54±12.61	43.09±11.49	.886
Foreward	>65	37.66+18.8	40.18±18.33	.586
Backward	>30	62.62+19.1	67.14±15.08	.322
Right	>65	63.21+14.17	62.68±15.63	.886
Left	>65	61.22+13.68	57.46±16.0	.297
Forward Right	>65	47.74+14.28	49.14±14.68	.700
Forward Left	>65	46.10+14.85	47.09±15.24	.793
Backward Right	>65	55.4+14.32	52.18±16.06	.389
Backward Left	>65	52.06+14.08	48.64±16.02	.357

Correlations

As shown in Table 3, significant correlations between BMI and SI were noted. Only directional control to the right LOS correlated with BMI. Injury did not correlate with SI or LOS except to the right.

Table 3: Pearson's Correlation Coefficients for BMI and injury vs SI and LOS.

Body mass index	Coefficients	p-value
Injury	0.056	0.62
SI EOFS	0.219	0.05
ECFS	0.213	0.05
EOSS	0.267	0.02
ECSS	0.232	0.04
LOS Right	-0.263	0.02
Injury with		
EOFS	0.041	0.71
ECFS	0.073	0.52
EOSS	-0.072	0.53
ECSS	0.003	0.98

Only conditions with significant changes were included except for the correlations with injury

Discussion

Approximately 27% of the participants in this study were injured as a result of playing soccer. This is similar to the study performed by Mtshali et al. (2009) who reported an injury prevalence rate of 33% in adolescent female soccer players.

In this study all participants met the inclusion criteria and hence had no discernable, proprioceptive, visual or vestibular disorders. Poor static balance related to the four SI assessments was probably linked to a somatosensory deficit in both groups. Participants would most likely have poor static balance if injured and hence have proprioception disruption. The static and dynamic balance in this study as reflected by the SI and LOS could have been affected by injury in the affected cohort. The insignificant differences between the injured and uninjured groups could be attributed to the fact that only about one third of the participants were injured compared to the two thirds that were not injured resulting in inequality of groups in statistical analysis. Odds ratios related to each of the four conditions under which SI was monitored show that when proprioception was impaired (EOSS) risk for injury was greater, in line with the findings by other investigators (Mandelbaum et al., 2009; Hrysomallis, 2007; Guerraz, Provost, Narison, Brugnon, Virolle & Bresciani, 2012). The risk for injury was lower when both vision and proprioception were impaired. However this may be related to compensatory responses of the other systems responsible for maintaining balance especially in the study cohort who were very young (Jaussen, 2012). Curiously when all senses were intact in the testing condition EOFS, OR for SI reflected more risk than when only vision was occluded. The findings in this study seem to suggest that proprioception trumps vision when static balance is concerned. Cornwall and Murrall (1991) who studied postural sway in individuals with acute ankle sprains found that there was a general increase in sway in those injured as opposed to those uninjured. Guerraz et al. (2012) suggest that when the kinesthesia of the knee joint is reduced, poor stability and static balance result.

As illustrated previously, the mean LOS values were poor for injured participants but not significantly different from the uninjured group. Hubbard et al. (2007) found a reduction in hip muscle strength following ankle injury. Female athletes have a greater average quadriceps activity and as emphasized by Mandelbaum and Putukian (1999) recruit the quadriceps before the hamstrings. Directional control in dynamic balance is related to the strategy employed to balance. Thus, injury to any of the muscles involved in the ankle strategy would lead to poor forward direction control. Winter (1995), believes that the ankle strategy is the first strategy recruited in leaning forward followed by the hip strategy. Hubbard et al. (2007) found a reduction in hip muscle strength following ankle injury. Female athletes have a greater average quadriceps activity and as emphasized by Mandelbaum and Putukian (1999) recruited the quadriceps before the hamstrings.

Ledin and Odkvist (1993) reported that a higher BMI can negatively affect balance and result in falls. Although the mean BMI in our study was normal, the significant correlation between BMI and SI under all conditions and BMI and LOS control to the right, regardless of injury suggests a link.

Conclusion

Significant correlations between BMI and SI were noted. Directional control to the right correlated with BMI. Injury did not correlate with SI or LOS. Odds ratios suggest SI with eyes open standing on a soft surface is associated with injury. Future studies could possibly include a larger sample size, evaluate participant injuries objectively, and undertake an in-depth assessment of injury.

References

Bahr, R. & Holme, I. (2003). Risk factors for sports injuries- a methodological approach. *British Journal of Sports Medicine*, 37, 384-392.

Biosway Portable Balance System Operation Manual (2010) Biodex Medical Systems Inc., Shirley, New York. www.biodex.com/sites/default/files/950460man_10202revc.

Cachupe, W.J.C., Shifflett, B., Kahanov, L. & Wughalter, E.H. (2001). Reliability of the Biodex balance system measures. *Measurement in Physical Education and Exercises Science,* 5(2), 97-108.

Choy, N.L., Brauer, S., & Nitz J. (2003). Changes in postural stability in women aged 20 to 80 years. *Journal of Gerontology*, 58A (6), 525-530.

Cornwall, M.W. & Murrell, P. (1991). Postural sway following inversion sprain of the ankle. *The Journal of the American Podiatric Medical Association,* 81,243-247.

Emery, C.A, Meeuwisse, W.H. & Hartmann, S.E. (2005) Evaluation of risk factors for Injury in Adolescent Soccer. *American Journal of Sports Medicine*, 33(12), **1882-1891.**

Faude, O., Junge, A., Kindermann, W. & Dvorak, J. (2005). Injuries in female soccer players. A prospective study in the German National League. *American Journal of Sports Medicine*, 33(11),**1694-1700.**

Gaerlan, M.G. (2010) The role of visual, vestibular and somatosensory systems in postural balance. *Unpublished Master's Thesis*, Las Vegas, University of Nevada, Las Vegas. NV.

Guerraz, M. & Day, B.L. (2005). Expectation and the vestibular control of balance *Journal of Cognitive Neuroscience*,17(3), 463-9.

Guerraz, M., Provost, S., Narison, R., Brugnon, A., Virolle, S. & Bresciani, J.P. (2012) Integration of visual and proprioceptive afferents in kinesthesia. *Neuroscience,* 223,258-268.

Hinman, M.R. (2000). Factors affecting reliability of the Biodex Balance System: A summary of four studies. *Journal of Sport Rehabil*itation, 9,249-252.

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

Hubbard, T.J., Kramer, L.C., Denegar, C.R. & Hertel, J. (2007). Contributing factors to chronic ankle instability. *The Foot and Ankle International Journal,* 28,343-354.

Jaussen, H. (2012). Measurement of balance disruption following a lower extremity injury in female soccer players. *Unpublished master's thesis* Utah State University, Utah, http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=2279&context=etd

Ledin, T. & Odkvist, L.M. (1993). Effects of increased inertial load in dynamic and randomized perturbed posturography. *Acta Oto-Laryngologica Journal,* 113,249-252.

Mandelbaum, B.R. & Putukian, M. (1999). Medical concerns and specificities in female soccer players. *Journal of Science and Sports,* 14(5), 254-260.

Mandelbaum, B.R., Silvers, H. J., Wantanabee, D.S., Knarr, J.F., Thomas, S.D., McLeod, T., Armstrong, T., Miller, M. & Sauers, T. (2009). Balance improvements in Female high school basketball players after a 6-week neuromuscular-training program. *Journal of Sport Rehabilitation*, 18,465-481.

Mtshali, P.T.S., Mbambo-Kekana, N.P., Stewart, A.V. & Musenge, E. (2009). Common lower extremity injuries in female high school soccer players in Johannesburg east district. *The South African Journal of Sports Medicine*, 21(4), 163-166.

Shaffer, S. & Harrison, A. (2007). Aging of the somatosensory system: A translation perspective. *Physical Therapy*, 87(2), 194-207.

Statistics South Africa (2013). Department of Sport and Recreation (2005). Participation patterns in sports and recreation activities in South Africa. Pretoria. Mid-year population estimates. *Statistical release.* P0302. www.statssa.gov.za/publications/P0302/P03022013.pdf. Accessed on 20 August 2013.

Steffen, K., Emery, C.A., Romiti, M., Kang, J., Bizzini, M., Dvorak, J., Finch, C.F. & Meeuwisse, W.H. (2013). High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: A cluster randomised trial. *British Journal of Sports Medicine*, 47(12), 794-802.

Winter, D.A. (1995). Human balance and posture control during standing and walking. *The Journal of Gait and Posture,* 3,193-214.