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原　著

閉眼片脚立ちテストで足関節及び膝関節周囲の外傷が予見できるか?

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A Study of the Ability of Single Leg Balance Test in Repeated Manner to Predict Ankle or Knee Injury

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Postural instability can be a risk factor to cause knee and ankle injuries. The single leg balance test (SLB test) is an easy –to-use approach to assess postural stability. The purpose of this study was to investigate whether repeated measurements of the SLB test predicts future ankle and knee injuries.

Eighty-five college American football players (Age: 20 ± 1 years) performed the SLB test at the beginning of each month of their regular season (September, October, and November). We classified the players into two groups based on the SLB test time; the positive group who could not maintain single leg balance for 10 sec; the negative group who maintained balance for more than 10 sec.

We did not find any significant difference between these two groups. However, the SLB test time was gradually decreased throughout the season. The SLB test time was significantly shorter in November than that in September. In conclusion, the SLB test performed in a repeated manner is less accurate to predict injury than a single measurement performed by a previous study.

【Key words】balance ability, prediction, ankle, knee, injuries

姿勢制御能力の不安定性は，膝関節や足関節周囲で発生する外傷の危険因子になることが判明している．閉眼片脚立ちはその姿勢制御能力を簡単に検査できるものであり，様々な現場や研究で用いられてきた．本研究では，この閉眼片脚立ちテストを繰り返し用いることによって足関節や膝関節周囲の外傷を予見できるか検証することを目的とする．対象者は，本学アメリカンフットボール部選手（85 名，平均年齢 20 ± 1 歳）とし，9，10，11 月の 3 カ月間，それぞれの月初めに閉眼片脚立ちテストを行ってもらった．10 秒以上行えた場合を陰性，10 秒以下の場合を陽性とした．結果として各月の陽性，陰性グループにおける外傷件数において統計学的有意差は確認されなかったが，各月のチーム全体の平均閉眼片脚立ちタイムは，9 月から 11 月にかけて有意に減少していくことが確認された．この結果を受けて，閉眼片脚立ちは先行研究と同様にシーズン初めに 1 回程度行う方が外傷を予見できる可能性が示唆された．

【キーワード】

Introduction

Injuries occurring to knee and ankle ligaments, i.e., ankle sprains and Anterior Cruciate Ligament (ACL) ruptures are some of most common injuries in the athletic population (Konradsen et al., 1997; Powell and Barber, 1999; Swenson and Fu, 1993). Considering the costs of the treatment and time loss subsequent to those injuries (Garrick, 1977; Powell and Barber, 1999), it is essential for coaches, players, athletic trainers, or sports doctors to screen and identify the individuals at risk for those injuries in advance. Some researchers have successfully predicted the susceptibility for ankle and knee injuries by using sophisticated tools such as a forceplate and isokinetic dynamometer (Payine et al., 1997; Tropp et al., 1984). However, those sophisticated machines are not available in most athletic fields. Furthermore, those machines are not advantageous in terms of time efficiency and mass screening.

It has been suggested that postural instability can be a potential risk factor to cause knee and ankle injuries (Hewett et al., 2001; Payine et al., 1997). The Single

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Leg Balance test (SLB test) is designed to measure to postural instability by standing one leg with eye closed, maintaining balance. This test is inexpensive, non-invasive, and expected to serve as one of the alternatives to aforementioned machines to assess postural stability. Trojan and McKeag (2006) used the SLB test as a tool to predict a future ankle injury for high school female and male athletes at preparticipation examination. They showed that the SLB test had successfully identified the susceptibility for ankle injury. To our knowledge, this is the only study that examined the validity of the SLB test to identify the risk of sports-related injuries, and the measurement by the SLB test was performed once at the beginning of the season.

During the SLB test, ankle, knee and hip joints play an important role in keeping balance (Dickin and Doan, 2008). Balance is highly dependent on proprioceptive information and neuromuscular control (Ellenbecker, 2000). Balance ability are influenced by some intrinsic factors such as fatigue, proprioceptive deficit, muscle weakness, and delayed muscle reaction time (Carpenter et al., 1998; Johnston et al., 1998; Kuioers and Keizer, 1998; Lattanzio et al., 1997; Miura et al., 2004). It has been confirmed that overtraining, resulting from an increase in training volume or intensity, can lead to prolonged fatigue and performance decrements (Kuioers and Keizer, 1998). Since the season continued for long time, the participants were likely to suffer from accumulated fatigue in a way similar to an overtraining because of repetition of a regular training and game. It was anticipated that accumulation of fatigue would influence balance ability. We expected the SLB test performed in repeated measurements could be a useful predictor of future ankle and knee injuries during a season.

In the present study, we hypothesize that the reliability of the SLB test for predicting risks of injury will increase by being regularly performed throughout a season. Based on our hypothesis, the first purpose of this study is to determine whether the regularly repeated SLB test can better predict future ankle or knee injury. The second purpose is to verify how the SLB test time will relate to the number of injuries with the progress of the season.

Method

Participants

A total of 94 Division Ⅰ male college football players ranging in age from 18 to 23 years (20 ± 1 years, mean ± SD) participated in this study (Table 1). We excluded 9 players whose knee or ankle had been injured before the season. The rest of them (85 players) had no history of ankle or knee injury in the last 3 months (June to August) before the season. Sixty-five players participated in all the measurements. Players were observed from September to November in 2007. Their regular season started in September and ended at the end of November. During the season, they had a competitive game every two weeks, and the total number of games was seven. All participants regularly performed weight training twice a week, following the instruction by a National Strength and Conditioning Association (NSCA) certified strength and conditioning coach throughout the season.

Injury Assessment

A certified athletic trainer at the college recorded all injuries. In this study, we defined an injury as any sprain happening to ankles or knees (1) that occurred during a formal practice or game; (2) that caused the player to seek medical care by a team physician or athletic trainer; and (3) that led to missing any practice or game subsequent to the injuries. We included only initial injuries to the ankle or knee for the analysis in our study. We excluded any further injury to same limb or injury to the opposite side. The reason for excluding the further injury was that the injured participant might be more likely to suffer further injury than normal ones because of the compromised functions such as poor postural control or functional instability (Lysholm et al., 1998; Tropp et al., 1984).

Single Leg Balance Test.

The procedure of the SLB test is described more fully in the previous studies (McGuine et al., 2000; Trojan and McKeag, 2006). In brief, the test comprises standing on one leg with the opposite leg not touching the stance leg; the eyes open and fixed on an instructor's finger; the hands on their iliac crest; then eyes closed for 180 seconds. One of the researchers checks whether the raised leg is touching the floor, or if the stance leg or the hands moves from the starting position. If the participant loses his or her balance within 10 seconds, participant is classified into the positive group. We classify the players who maintain balance more than 10 sec into the negative group. We set 10 sec as a cut-off time based on

the previous study (Trojan and McKeag, 2006) and this cut-off time was considered to be clinically relevant. Emery et al. (2005) showed that the test-retest reliability was adequate to use SLB test as a balance measure for adolescence based on intraclass correlation coefficient ([ICC] =.69). Although participants performed SLB test once before the season in the previous study (Trojan and McKeag, 2006), they performed SLB test once for each leg at the beginning of every month when they were not injured in the present study.

Statistical analysis

Statistical analyses were performed using the SPSS statistical package (version 16.0; SPSS Inc, Chicago, IL). Mean and SD were calculated in the descriptive analysis. Chi-square analysis was applied to examine the difference of injury rate between groups and repeated analysis of variance (ANOVA) was used to examine the transitional change of SLB test throughout the season. If Mauchly's sphericity test was rejected, the modified degree of freedom by Greenhouse-Geisser epsilon would be used. The *Scheffe* Method of Post hoc Analysis was used when there was a significant difference. We set our alpha level at .05.

We calculated Team Mean Time (TMT) for each month based on 65 players who participated in all the measurements in order to keep track of transitional change throughout the season. Some players were not able to complete all SLB test because of injuries happened during a season.

Result

During the course of the study, 13 sprains happened in the 85 American football players (September: 4 injuries, October: 3 injuries, November: 6 injuries. Chi-square analysis did not show any significant difference in the number of injuries for each month between the positive and negative groups (Table 1 – 6).

According to the monthly TMT, the TMT in September was the highest among all months. Post hoc analysis revealed the significant difference in the TMTs between September and November ($p<0.05$) (Figure 1). Trend analysis showed a significant monotonic trend in TMT [$F(1.64)=6.350$, $p=0.014$, $\acute{\eta}^2=0.90$], indicating that the monthly TMTs significantly descended throughout the season.

Table1 Single leg balance test and ankle and knee inuries based on September data (Positive group.No injury history for past 3months)

		Injured	Uninjured
SLBT	Positive	2	27
	Negative	1	24
		($\chi^2=0.215$, $p=>0.05$)	

Table2 Single leg balance test and ankle and knee inuries based on September data (Negtive group. Injury history for past 3months)

		Injured	Uninjured
SLBT	Positive	1	7
	Negative	0	11
		($\chi^2=1.451$, $p>0.05$)	

Table3 Single leg balance test and ankle and knee inuries based on October data (Positive group.No injury history for past 3months)

			Injured					Uninjured
SLBT	Positive		1					37
	Negative		1					25
			($\chi^2=0.075$, $p>0.05$)					

Table4 Single leg balance test and ankle and knee inuries based on October data (Negtive group. Injury history for past 3months)

			Injured					Uninjured
SLBT	Positive		0					10
	Negative		1					9
			(χ^2=1.053, p > 0.05)					

Table5 Single leg balance test and ankle and knee inuries based on Nobember data (Positive group.No injury history for past 3months)

			Injured					Uninjured
SLBT	Positive		4					31
	Negative		0					13
			(χ^2=1.621, p > 0.05)					

Table6 Single leg balance test and ankle and knee inuries based on Nobember data (Negtive group. Injury history for past 3months)

			Injured					Uninjured
SLBT	Positive		1					12
	Negative		1					9
			(χ^2=0.038, p > 0.05)					

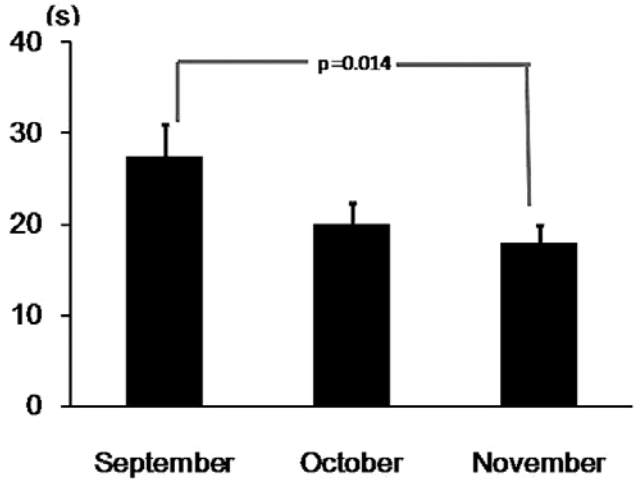

Figure1, Team mean time throughout the season. There was the significant difference between September and November (P<0.05). Trend analysis showed significant monotonic trend in TMT (P<0.05).

Figure1

Discussion

McGuine et al. (2000) found that preseason measurement of postural sway predicted susceptibility to ankle injury. Tropp et al. (1984) found that participants with ankle instability were more likely to suffer an ankle injury. However, Pre-season screening test conducted by us was not able to find any susceptibility to ankle or knee injury

as well as significant difference in the number of injury between positive and negative group with or without history of lower limb injury.

Trojan and McKeag (2006) found a relatively higher risk of injury in the group whose SLB time was less than 10 seconds with neither history of ankle sprain nor having taped their ankle. Our finding partially corresponded with this previous study in that the positive group without history of injury was likely to get injured.

During the athletic performance such as running, the body goes out of base of support, losing balance and regains it as the leg moves forward (Irrang et al., 1994). In other words, the major joints of the lower limb, which is composed of hip, knee and ankle, need to collaborate to move the Center of Gravity (COG) back to the base of support while maintaining balance (Guskiewcz and Perrin, 1996). In order to perform such collaborative activity, appropriate propriocetive feedback through the Central Nervous System (CNS) is necessary for accurate muscle activation to control joints (Irrang et al., 1994). Therefore, testing positive in the SLB test may reflect poor ability to keep COG within the base of support during the athletic performance and abnormal coordination control between muscle activation and proprioceptive information, leading to predisposing the players to suffer ankle or knee injury.

In the present study, a trend analysis showed that monthly TMT became smaller in a monotonic manner as the season went on. We found a significant difference in the monthly TMT between September and November. Some researchers (Johnston et al., 1998; Miura et al., 2004) have speculated that acute muscular fatigue has been associated with impaired proprioceptive information. Skinner et al. (1986) found that ligamentous laxity was increased after a fatigue bout. Ligamentous laxity decreases the sensitivity of mechanoreceptors, resulting in impaired proprioceptive information. It is possible that poor performance in the SLB test is that impaired proprioceptive feedback secondary to fatigue complicated the process in which the CNS controls the skeletal muscle.

There is a evidence that acute fatigue can hinder a proprioception (Johnston et al., 1998; Miura et al., 2004), leading to poor balance ability. However, in our study, the participants performed the SLB test under stable conditions without acute fatigue. In terms of fatigue effect, a decrease in TMT through the season may, to a large extent, be due to cumulative fatigue due to repetition of a regular training and game.

Given that decrease in TMT is associated with an accumulated fatigue, one may expect that the number of injury would increase as a season goes on. In fact, the number of injuries gradually increased as the season went on in the present study (September: 4 injuries, October: 3 injuries, November: 6 injuries). The greatest number of injuries in November may suggest that cumulative fatigue impaired propriceptive information, resulting in an increase in risk for ankle or knee injury.

In the study performed by Trojian and McKeag (2006), the participants performed the SLB test at one time. However, in our study, the SLB test was performed in the repeated manner and showed less accurate in detecting the risk of injuries than the one performed at one time. Therefore, we recommend that the SLB test should be performed at one time, especially before a season starts.

Accurate muscle activation to control the joints of lower extremity based on precise propriocetive feedback is an essential component for balancing during the athletic performance (Irrang et al., 1994). It has been reported that ankle disk training was able to decrease the number of ankle sprain (Tropp et al., 1985) as well as improve postural control (Gauffin et al., 1988). Therefore, balance training such as ankle disk training can be an effective prevention for lower limb injury.

Most of mechanisms underlying sports-related injuries are related to dynamic activities such as running, cutting and pivoting. Indeed, the ankle and knee injuries have occurred during those dynamic activities (Emery et al., 2005; Hewett et al., 2001). Since the SLB test is performed under static condition, the result may not directly be reflective of the ability of dynamic balance. In the future study, the test directly assessing dynamic balance, i.e., a Star-Excursion test may need to be also included.

A potential limitation in our study is that knee sprain injuries were included unlike other previous studies. Based on the kinetic chain concept, knee can be one of the major contributors to maintaining postural control (Dickin and Doan, 2008) and has been proved to be affected by fatigue, resulting in increasing injury risk for knee ligamentous injury (Lattanzion et al., 1997). Taken those facts together, predicting knee injury by the SLB test would be reliable enough and based on theoretical rationale if the test is performed in the appropriate manner.

Conclusion

The SLB test is an inexpensive, safe, and can be reliable test to detect the risk of injury when used in a prospective manner. Additionally, this test can potentially be a mass-screening as well as a fast alternative method compared to sophisticated tools. In conclusion, we recommend that the SLB test should be performed at one time before a season to predict future ankle or knee injuries. Moreover, there is the need for further study to examine the reliability of the SLB test to detect future injury.

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