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原　著

Hopテストによる下肢の外傷を予見する試みについて

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Hop Test as A Predictor for Lower Limb Injuries

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A hop test has been proposed to assess the CKC function in the lower extremities. However, to our knowledge, there is no study to examine the ability of a hop test for predicting future injuries in the lower extremities. We randomly chose Sixty-seven college American Football players and they performed a Single Leg Hop Test (SHT) and a 6-meter Timed Hop test (THT) for each leg before the season. The players were classified into below-average (BA) and above average (AA) groups according to the score of the SHT and THT, respectively. A certified athletic trainer recorded two types of injuries throughout the season: muscles strain occurred to thigh or calf and ligamentous injuries occurred to knee or ankle. The incidence of those injuries was compared prospectively.

Chi-square analysis found a significant difference ($p < 0.05$) in the number of muscle strain injuries between the BA and AA group in the THT (Table1), but not in the SHT. Furthermore, Kaplan-Meier analysis with the use of the log rank test showed that BA group had significantly higher percentage of lower limb injury than AA group had in THT. The individuals with lower physical ability in the THT have a higher risk for lower limb injuries. A Timed Hop test may open the possibility to be used as a screening test for lower limb injury.

【Keywords】hop test, screening test, lower limb injury

Hop test は高価なオープンキネティック（OKC）の機械の様な高度な解析は出来ないものの，クローズキネティック（CKC）の状態で計測出来るため，本来の運動動作の特異性をより反映した実用的なテストであると言える．本研究では，本学アメリカンフットボール選手を対象とし，2008 年シーズン前に Single Leg Hop Test（SHT）と 6-meter Timed Hop test（THT）の 2 種類を実施してもらい，シーズン中に下肢で発生した肉離れ，捻挫とどのように関連しているかを検証する前向き研究を行った．観察期間は，4 月から 11 月までとし，全米アスレチックトレーナー協会（National Athletic Trainers' Association; NATA）公認アスレチックトレーナーが外傷の収集，記録を行った．

結果として, THT において平均以下のグループ（Below-Average; BA）は平均以上のグループ（Above-Average; AA）より，有意に肉離れ受傷件数が多かった．（$p<0.05$） また，カプラン - マイヤーの生存時間分析では，THT の BA グループが有意に下肢の受傷割合が多いことが確認された．（$p<0.05$）今回の研究により，Hop test が運動選手，特にコンタクスポーツの選手に対するスクリーニングテストとして使用できる可能性を示唆した．

Ⅰ．Introduction

Some sophisticated machines such as isokinetic dynamometer (e.g., Biodex) are relatively reliable tool to predict susceptibility to injury (e.g., hip flexor strain or ankle sprain) (Willems et al., 2005; Tyler et al., 2000). The assessment is, however, limited to an Open Kinetic Chain (OKC) condition despite that most injuries in athletic fields occur under a Closed Kinetic Chain (CKC) condition (e.g., running, cutting or pivoting).

There are some field tests such as a single leg stance test or hop test performing under a CKC condition. A hop test has been introduced to assess lower extremity function after the surgery for anterior cruciate ligament (ACL) injury. Recently, a hop test has been proposed to assess the CKC function in the lower extremities (Booher et al., 1993).

Although hop test cannot show the accurate analysis of

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lower limb function conducted by isokinetic machines or 3dimesionnal studies, hop test can show the wide range of lower extremity functions such as neuromuscular coordination, muscular strength, and joint stability (Barber et al, 1990). Therefore, we believe this test cannot only be used to assess lower extremity function, but also used to be a screening test for a future injury. However, to our knowledge, there is no study to examine the ability of a hop test for predicting future injuries in the lower extremities.

Ⅱ. Method

1. Participants

We randomly chose Sixty-seven college American Football players (21.1 ± 1 years, mean ± SD) (Table 1) at Doshisha university and they performed a Single Leg Hop Test (SHT) and a 6-meter Timed Hop test (THT) for each leg before the 2008 season. The players were classified into below-average (BA) and above average (AA) groups according to the score of the SHT and THT, respectively.

Players were observed from April to November in 2008. Their season started April and ended in November and they had 14games (spring; 6, fall; 7, postseason; 1). 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.

2. Single Leg Hop Test (SHT)

The participant stranded one leg, hopped and landed on the same leg. We measured the distance from the toe in the starting position to the heel where the subject landed. SHT was performed twice with each leg. Data from the right and left limb trials were averaged. Booher et al. (1993) showed that the test-retest reliability was adequate to use SHT to measure lower extremity performance based on intraclass correlation coefficient ([ICC] =.99).

3. 6-meterTimed Hop Test (THT)

The participant was instructed to stand one leg at a start line and to hop 6 m on one leg. We set up optical measuring instrument with remote control system at both start and finish lines (Race time 2, Microgate S.r.L, Italy, Bozen). Therefore, time was automatically recorded by this instrument when the subject crossed the finish line. Booher et al. (1993) showed that THT were reliable and appeared to be acceptable to measure lower extremity performance (ICC=.77).

4. Injury collection

NATA certified Athletic Trainer collected all injuries. In this study we recorded two types of injuries throughout the season: muscle strain occurred to thigh or calf and ligamentous injuries to knee or ankle. In this study, we defined an injury as any event (1) that occurred during a regular practice or game; (2) that caused the player to seek medical care by a team physician or the athletic trainer; and (3) that led to missing any practice or game subsequent to the injuries. The team doctor made the final diagnosis. The incidence of those injuries was compared prospectively.

Table 1. Characteristics of 67 players who performed SLB tests

Charactersitics	Mean	SD	Range
Age,y	21.1	1.0	20-24
Height,cm	173.6	5.0	162-185
Weight,kg	77.1	12.1	60-107
BMI	25.5	3.7	19-36

Table 2. Timed hop test and muscle strains

	Injured	Non-injured	Total
Below-average（BA）	14	15	29
Above-average（AA）	8	31	39
	22	46	Total

χ^2=5.858, $p < 0.05$

5. Statistical analysis

We used Student's paired t-test, chi-square analysis and analysis of variance (ANOVA) Post hoc testing was used to assess pair-wise differences. Kaplan-Meier analysis with the use of the log rank test was used to compare BA and AA groups. Since the time to first injury was important due to the increased possibility to get another injury or change basic physical characteristics such as muscle strength or proprioception, we observed all subjects throughout the season and defined as the end of the season when they got a first injury. Months to injury was chosen as the time variable. We set our alpha level at .05. SPSS software for Windows (Japanese version 17.0: SPSS Japan Inc, Tokyo, Japan) was used for all analysis.

Ⅲ. Result

During the course of the study, we confirmed 30 sprains and 22 muscle strains.Chi-square analysis revealed that the below-average (BA) suffered significantly higher number of muscle strain injuries than the above-average (AA) in THT ($p < 0.05$) (Table2). Mean time in BA group was significantly lower than the one in AA group ($p < 0.05$) (Figure 1). Figure 2 shows Kaplan-Meier analysis for time to first lower limb injury according to THT time. It was found that there was a significantly increased percentage of lower limb injury for BA group compared with AA group ($p < 0.05$).

Ⅳ. Discussion

Although some previous studies tried to predict a future injury by using a OKC machine (Tyler et al., 2000) and CKC test under static condition (Trojan and McKeag, 2006), to our knowledge, our study was first attempt to predict future injuries by using a hop test.

Our result showed that BA group for THT sustained the significantly higher number of muscle strains than AA group. Furthermore, there was a significant difference in mean THT time between BA and AA group. Actually, Tyler et al (2001) conducted prospective study by using professional ice hockey players who belonged to National Hockey League (NHL). In their study, all participants (the 1997-1998season: 46players, 1998-1999season: 55players) were assessed for their hip flexion, abduction, and adduction strength with OKC machine before the seasons. The result showed that the mean hip adductor strength for the player who sustained hip adductor strain was significantly lower than the one for uninjured players.

Considering that muscle strength assessed by a hop test was significantly correlated with the one by OKC machine (Petschnig et al., 1998), our results may mean that muscle strength weakness is potentially liked to muscle strains. Simultaneously, from the point of view of cost, this result is beneficial to the health care providers (e.g., athletic trainer or physical therapist) with no available OKC machine, especially who need to conduct a screening test in determining the athlete at higher risk for a sports-related injury.

Kaplan-Meier analysis with the use of the log rank

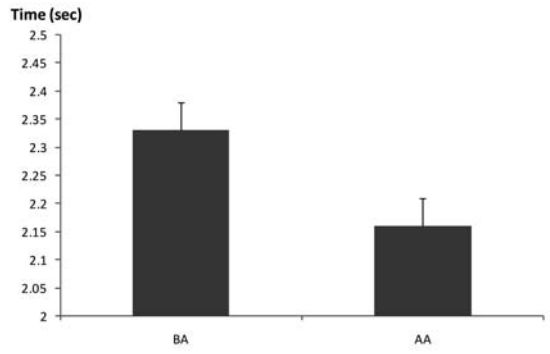

Figure 1, Mean THT time between Below-Average (BA) and Above-Average groups (AA). There is a significant difference between BA and AA ($p < 0.05$).

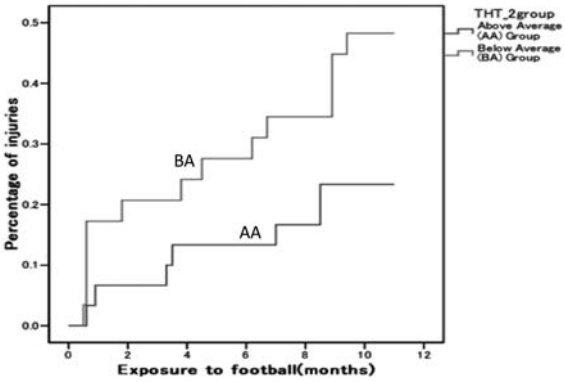

Figure 2, Survival curves based on Kaplan-Meier analysis with the use of the log rank test. There is a significant difference in survival between BA and AA group in THT ($p < 0.05$).

test showed that BA group had significantly higher percentage of lower limb injury than AA group had.

As described above, this analysis was based on the number of injures that we counted throughout the season. In other words, this result means time-dependent change in the number of injury. Typically, a regular collegiate American football season starts September and ends November. This time schedule leads us to believe that cumulative fatigue or mental pressure of the players could be increased as the season progresses, resulting in increased risk for injury.

According to the study conducted by Iguchi et al (2011), they performed the study for collegiate football players and recorded their time for single leg balance test at the beginning of each month from September to November. The result showed that the mean time of single leg balance test was significantly decreased as the season progresses. This was mainly explained by the cumulative fatigue. Furthermore, other studies have indicated that muscular fatigue has impaired proprioception(Johnston et al., 1998; Miura et al., 2004) and increased joint laxity (Skinner et al., 1986), leading to predisposing the players to suffer lower limb injury. Based on those findings above, we can assume that, for some reason, BA group were more affected by cumulative fatigue than AA group, and thus more joint laxity and impaired proprioception resulting in the higher number of lower limb injuries for BA.

In general, muscle increases its risks for strain when they are overly stretched out (e.g., eccentric contraction) (Garrett., 1996). Garrett (1996) examined how much energy muscle can absorb when they were stretched and compared activated with passive condition. His result showed that activated muscle can absorb about twofold energy compared to passive one. Garret concluded that muscle by itself has the ability to absorb energy as well as to prevent itself from sustaining strain injury. In other words, this study indicated that the stronger muscle, the more energy they can absorb. Furthermore, Mair et al (1996) conducted the study comparing the amount of energy of fatigued and non-fatigued muscle. The study showed that fatigued muscle absorbed less amount of energy than non-fatigued muscle did, indicating that fatigue can be a predisposing factor to cause muscle strain. Taking into account those results above, in our study, BA group who had lower muscle strength were more likely to be affected by fatigue and decreased the ability to absorb energy, leading to the higher percentage of lower limb injury, especially muscle strain.

Ⅴ. Conclusion

This study showed the possibility to predict lower limb injury such as sprain and strain. On the other hand, we found some limitations. To take one example of them, it still remains unknown about how fatigue affected the participants during the course of season. In addition, we did not analyze the side-to-side difference in SHT and THT although some previous studies focused on it as a predisposing factor. Therefore, there is needed for further study in determining whether the side-to-side difference has a potential link to injury or how fatigue affects a lower limb injury in more detail.

Our result showed that the participants who had less ability to perform THT were more likely to sustain lower limb injury. More importantly, in our study, a hop test performed as a screening test successfully detected the participants at higher risk for injury in a manner similar to the previous study used by OKC machine. This opens the possibility that a hop test can be used as a screening test and also beneficial to the health care providers with no available to OKC machine.

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