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Effects of proprioception training on knee joint position sense in male soccer athletes

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Abstract

The aim of this study was to examine the effect of proprioception training program on knee joint position sense in male soccer athletes. Reproduction of knee joint angle by a passive (by the examiner) - active (by the subjects) positioning was employed to measure joint position sense. Thirty male athletes (N=30) were participated in this study from Sports Science faculty at Mutah University whom registered in soccer course for Fall semester 2013/2014. The researcher used the non-dominant as an experimental limb and underwent proprioceptive training program and dominant as a control limb. The researcher used paired-sample and independent-samples-t- Test to analyse the absolute angles score of present study.

Results indicated that there was a significant difference of reproduction of the knee joint angle before and after intervention training for the non-dominant limb and a significant difference between dominant and non-dominant limb after intervention training program, ($p \leq 0.05$).

It was suggested that using a proprioception training program may have a direct impact in decreasing knee joint injuries in male soccer athletes.

Keywords: proprioception, joint position sense, reproduce joint angle, male soccer athletes, training program.

Introduction

Most physical activities entail certain risks of injuries, whether acute or chronic. For most professional and non-professional athletes, these injuries are accepted in return for the ultimate reward that comes from participation in sport activities. Athletes who participate in sport activities which required changing of direction, rapid deceleration and spontaneous stopping such as basketball, volleyball and football (soccer) have the highest percentage of injury (Eisenhart et al., 2003). For example, Fifa (2008) reported that Football (soccer) has been representing as the world's most popular game, with more than 265 million registered players all over the worlds and continue to do so. Injury is the main factor that effect athlete's availability for all levels of sports (Lauersen et al., 2014;Hagglund et al.,2013; Parry and Drust, 2006). For example, top Europeans clubs have a mean of 14% of players to be unavailable because of injury at any one time; with players have at least two injuries a season (Ekstrand et al., 2013). This causes a direct impact on team performance and its results (Hagglund et al., 2013); as well as seriousness of sport injuries is considered costly in term of time, money and coast (Schoon, 2005; Boden et al., 2000). So, coaches, trainers and fitness instruction must concentrate on training program that provides prevention for sport injuries among athletes. Therefore, different programs and methods were provided for the purpose of preventing sport injuries; such as, strength training, flexibility and most important is proprioception training (Eils and Rosenbaum, 2001).

The role of the proprioception training and muscle activations is less considered in term of promoting of knee joint and subsequently the anterior cruciate ligament (ACL) stability which may reduce the risk of injury among player s(Mandelbaum et al.,2005). Proprioception has been defined as "the inherent kinesthetic awareness of body posture including movement, tension and change in equilibrium" (Baltaci and Kohl, 2003).

Proprioception encompasses both static and dynamic aspect of position sense (Swank et al., 1997). Static sense tells us where you are in space, whereas dynamic sense gives the neuromuscular system feedback about the rate and direction of movement. Therefore, proprioception as complex of neuromuscular process contains an afferent and efferent signal which allows the body to maintain both stability and orientation (Bruhn et al., 2001).However, proprioception training activities in the different part of the sensory and motor system which entailed in joint stability and enhance the motor-sensory system function ; in the same time the lack of tension to the proprioception training may reduce the joint proprioceptive sense, muscle strength, muscle tone and knee kinesthesia. This lead may be to repeated ligamentous lesion and subluxation of knee joint and subsequently ACL (Baltaci and Kohl, 2003). Accordingly, many types of training intervention have already been applied as means to reduce injuries. For example, Sadoghi et al. (2012) showed that the incidence of anterior cruciate ligament (ACL) injury could be reduced by 52% in females and 85% in males by using a proprioceptive neuromusculer training program. Also, Caraffa et al. (1996) showed that the reduction of ACL injuries by sevenfold (0.15 injuries per team per year) after proprioceptive training program when he compared experimental to control groups. Furthermore, proprioception training program to the perceptive information which are found in ligament, muscles, tendons and mechanoreceptors in and around the knee joint offer information about the change of position and motion to athlete in order to correct any sudden movement during multi- joint movement which may have direct impact to prevent any serious injury to knee joint during sports activities (Baltaci and Kohl, 2003). Therefore, proprioception training attempt to maximize protection from any injuries and provide optimal functional activities to the knee joint during sport activities.

Most of previous studies assessed the outcome of their training program in terms of muscular or ligament injuries over the subsequent soccer season(s)(Caraffa, et al., 1996; Hewett, et al., 1999; Junge, et al.,2002). The results of above studies show dramatic reduction in terms of injury occurrence observed when training lasted at least one season. However, none of the researchers in the previous studies use any form of specific neuromuscular and sensorimotor analysis to determine what aspect performance may have contributed most to the observed reduction in injuries treated statistically. The neuromuscular and sensorimotor performance represents the aspect of real-life scenario that we have daily and all athletes used during their participation in sports games. The action and reaction response during sports activities depends on available response time (Swanik et al., 1994). Therefore, an efficient muscle reaction time may be required for injury prevention during games. Examining athletes dynamic sensorimotor ability may be more able to assess how the body response during real life and sports activities. Furthermore, examining in rapid joint reproduction task represents more specific sport activities during games scenario. Therefore, the purpose of this study was to investigate the effects of proprioception training program on knee joint position sense over six weeks. This time period was selected to represent a typical period between two seasons during the year of participation.

Literature Review

The lower limb injuries are commonly reported among athletic populations, particularly in team sports athletes. The knee joint is consided one of major joints in the body and the most frequently injured one; and a serious disruption to knee ligaments is frequent (Hiemstra et al., 2001). The degree of injury of the knee joint and subsequently ACL depends on the interaction between the passive structure (osseous geometry, ligaments, menisci and capsular structure) with muscle stabilizers (Fu et al., 1993). There is accumulating evidence of knee ligament injuries by non- contact mechanisms (Ireland et al., 1997). For example, Grinsven et al. (2010) reported that the incidence of knee injury is 48 per 1000 patients per year. Nine (9%) of these cases, there is damage incident to one or more ligaments, of which the anterior cruciate ligament (ACL) is the most commonly injured. Most ACL injury occur during sports activities and take place between 0 and 30 degree knee flexion (Cerulli et al., 2001).

Many factors are contributing to instability of knee joint during sport activities such as decrease range of motion, decrease strength of knee extensors and subtalar, and decrease in joint proprioception (Baltaci and Kohl, 2003). Proprioception includes the senses of joint position and joint motion. The sensory information, central processing and neuromusculer control are so important to achieve stability to knee joint (Nagai et al., 2013). However, any proprioceptive deficit may lead to an alteration in joint stability and control of joint motion (Lattanzio, et al., 1997).This implies that injury prevention measure could benefit athletes and enhancing the athlete's chance to success. Therefore, proprioception training programme is so important for promoting dynamic joint and functional stability in any sport games to prevent injury (Blackburn et al., 2000). Numerous studies have looked at the effects of strengthening and proprioception exercise or a combination of both to maximize the reduction of sports injuries among athletes and to enhance functional performances as well as activities (Elis and Rosenbaum, 2001). For example, Hewett, et al (1999) shows the importance of polymeric training in preventing knee injuries in female's athletes. Following 6- weeks training, result indicated that there is a reduction in the rate of injury from 0.43 per 1000 exposure to 0.12(P $\leq$ 0.05).Also, Hubscher,et al. (2010) made a systematic review to evaluate the effectiveness of proprioceptive training in preventing sports injuries by using the available information from methodologically well-conducted randomized controlled trials and controlled clinical trials without randomization. They concluded that only 7 studies out of 32 were considered for this review Pooled analysis revealed that multi-intervention training was effective in reducing the risk of lower injuries (RR=0.61,95% CI= 0.49-0.77 P< 0.01), acute knee injuries (RR=0.46, 95% CI=0.28-0.76,P< 0.01), and ankle sprain injuries(RR=0.50 95% CI=0.31-0.79, P< 0.01). Balance training alone resulted in a significant risk reduction of ankle sprain injuries (RR=O.64, 95% CI=0.46-0.9, P 0.01) and a nonsignificant risk reduction for injuries overall (RR=0.49. 95% CI=0.13-1.8, P= O.28). Exercise interventions were more effective in athletes with a history of sports injury than in those without.

Furthermore, Wang et al. (2009) reported that a regular participation has positive and a direct impact on proprioceptive exercise, physical functioning, improve gait mechanics and increase of flexibility at or around knee joint. For example, Panics et al. (2008) demonstrated a prospective cohort study to determine the contribution effects of proprioception on knee joint position sense among team handball players. The researchers used two professional female handball teams were followed prospectively for the 2005-2006 season. 20 female's athletes were used as experimental group and followed a prescribed proprioceptive training program and 19 female's athletes did not have any specific proprioceptive training programme. The result of the study indicated that the proprioception sensory function of the athletes in the intervention team was significantly improved between the assessments made at the start and at the end of the season (mean (SD) absolute error 9.78-8.21 degree (7019-6.08 degree) VS 3.61-4.04 degrees (3.71-3.20 degree) p<0.05. No improvement was seen in the sensory function in the control team between the start and at the end of the season (mean (SD) absolute error 6.31-6.22 degree) VS 6.13-6.69 degrees (7.46-6.49 degrees), p>0.05.

This gives some evidence that proprioception around and within the knee joint could be trained and make a big difference for many athletes to avoid major injuries during competitive seasons. Proprioception has been measured clinically as the ability to reproduce joint angles and threshold of detection of passive movement (Barret, 1991; Corrigan et al., 1992; Dvir et al., 1988). The most frequently used method is based on the ability to detect a passive movement and the ability to reproduce a knee joint position by active repositioning of the knee joint (Jensen et al., 2002; Panics et al., 2008).

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Method

Subjects

Thirty healthy males' collegiate athletes who played soccer from Sport Science Faculty at University of Mutah were chosen and assessed. Physical characteristics are presented in table (1). Excluded were subjects who had a history of lower limb injuries. The subjects were instructed not to participate in any heavy exercise 24 hours before testing. All participants were assigned their non-dominant limb to the intervention training program as it believed that a greater improvement to neuromuscular and sensorimotor ability (June et al., 2002). The training program period was 6-weeks.The same test administrator take all measurements.

Table 1: Physical characteristics of the participants (mean± SD)

Group	Age	Height	weight
Subjects	20.87 ±0.90years	1.70±6.48 m	65.45±7.75 kg

Training Program

The program of exercise was designed to mimic the situation the athletes encountered during the sporting activities as recommended by (Panics et al., (2008); Hewett et al., (1999); Caraffa et al., (1996); in addition to provide a stimulus for the improving of neuromuscular performance. The training program carried out over six week's period. All participants involve in a total of three exercise sessions per week. Following habituation procedures, each participant completed a standardized warm-up which consists of five minutes on a cycle ergometer and further five minutes of static stretching of the involved musculature. The training sessions lasted approximately 15-20 minutes (5 minutes stretching, 5 minutes cycling and {10-15} minutes training) a day by 3 days a week, on alternating days. Subjects group documented their repletion in the training manual. The program was divided to 8 Levels as the following:

Level-1: (1-leg stance on the ground), non-preferred limb. The player had to demonstrate proficiency in each level before progression to next level.

Level-2: The players instructed to perform balancing movement while standing on the non-preferable limb with open and close eye on a alternative manner.

Level-3: The players informed to perform hopping on non-preferable limb between squares (random movement) in all direction- emphasis on the accuracy of the movement.

Level-4: The players informed to perform on non-preferable limb between floor markers in a figure of eight fashion.

Level-5: The players informed to perform on non-preferable limb between floor markers in a figure of eight fashion but with less space between markers.

Level-6: The players informed to perform on non-preferable limb jumping up in the air with emphasis on soft landing and accuracy to land with the designated box on the floor.

Level-7: The players informed to perform on non-preferable limb hopping in the middle esquire box, concentrating on accuracy.

Level- 8: The players informed to perform on non-preferable limb hopping in the middle esquire box, concentrating on accuracy and height of movement.

Notes: These exercises were developed and designed by Professor Nigel Glesson, department of kinesiology in the School of Health, Sports and Science. University of Wales, Bangor, UK.

Joint position sense (JPS) measurement

The subject was placed in prone position on a medical bed. A strap was positioned over low back to prevent any movement during testing and lower limb is off the bed approximately 5 centimeters to make the leg straight forward. A gonimeter was used to record the knee angles. The gonimeter was positioned midway between the lateral condyle of the tibia and the lateral epicondyle of the femur consistent with the anatomical axis of the knee joint. The goniometer was zero before tests in each position. Each participant was given two trials to become familiar with the procedure. From 25º of knee flexion (middle range of the test position, which as it is known that this position thought to be mechanical threat to the knee stability), the examiner passively the limb to different angles ranges from 10º to 80º degrees. After holding the limb in this position approximately 2 seconds, the limb was returned to the starting position and the participant asked to return the limb to the position at which it had originally been placed by the examiner (Panics et al., 2008). To eliminate a learning effect, participants were blindfolded to prevent visualisation of the leg and did not receive any feedback on the accuracy of their estimates. The difference between the angle set by the examiner and the angle into which the participant put his limb was calculated.

Statistical Analysis

Position sense angles measurement was recorded as the absolute angles errors of the difference between the angles sit by the examiner and subject, ignoring the direction of the error. To examine any significant differences between pre and post measurements for the non-preferred limb, the paired-samples t-Test was used; also to examine any significant difference between the post measurements for the non-preferred and dominant limb, the independent-samples t-Test was used. For both test the researcher used eta squared to examine effects size between means according to Cohen guideline. A p-value of ≤ 0.05 was considered statistically significance. SPSS (V19) was used to perform all statistical procedure.

Results

All thirty males subjects were successfully completed the study. There was a significant difference between the non-preferred limb before and after the intervention program [table 2]. The effect size was (92%) and according to Cohen guideline the proprioception training program has large effect on knee joint position sense in male soccer athletes**.** Also, there was a significant difference between non-preferred and preferred limb after the intervention of proprioception training program [table 3].The effect size was (72%) and according to Cohen guideline the proprioception training program has large effect on knee joint position sense in male soccer athletes**.**

Table 2: Comparison of results of the non-dominant limb before and after intervention training program

Measurement	Mean±SD	Degree of freedom	T-value	Significant at 0.05 level	Effect size
Pre-test	4.53±0.51	29	18.88	0.00	0.92
post-test	1.80±0.61				

Table3: Comparison of results of the dominant and non-dominant limb after intervention training program

Measurement	Mean±SD	Degree of freedom	T-value	Significant at 0.05 level	Effect size
Pre-test	4.20±0.88	58	12.21	0.00	0.72
post-test	1.80±0.61				

Discussion

This endeavor is considered the first potential study to report the effects of proprioception training on knee joint position sense in male athletes in physical education male's student from Sport Science Faculty at Mutah University. The results of this study indicated that there is a significant an improvement of proprioception around the knee joint as indicated in table (2 and 3) after training programme. This improvement is sufficient evidence for the detection of the change of performance among athletes in physical education male's student at Mutah University during 6-weeks training program. For example, Caraffa et al., 1996 examined a proprioceptive balance training program using 600 semi-professional armature soccer players in Italy. The study consisted of a 20-minute training program divided into 5 stages of increasing degree of difficulty. The prospective study was completed over the duration of 3 completed soccer seasons. The results indicated that the injury of ACL was reduced by sevenfold (0.15 injuries per team per year) after proprioceptive training program compared to control group. Furthermore, according to the protocol of this study, was used the non-preferred limb as the experimental limb, as greater potential for both sensorimotor and neuromuscular gain may have been expected after training program.

This expectation was achieved as indicated by the result of this study. This consistent with Gollhofer, et al. (2000) who reported that the musculature encompassing the knee joint system can be effectively trained, where as these musculature system are controlled by the signals of afferent and efferent during sport activities. Consequently, a preventive training program to improve neuromuscular and sensorimotor function of the lower limb musculature and as a result the knee joint stability may be a cost an effective approach to the prevention injury. For example, Myklebust et al., (1998) demonstrated a proprioceptive training program in elite female team handball players. The study consisted of 5 phase of training program which consisted form floor exercise, wobble board activities and a balance mat performed 2to 3 time per week over a period of 5 to 7 weeks in the pre-season and once a week during the season. 85 teams (855 players) participated in the first season (1999-2000) and 52 teams (850 players) participated in the second season (2000-2001). 60 teams (942) in the 1998-1999 seasons served as the control. The result indicted those 29 ACL injuries in the control season whereas 23 and 17 ACL injuries in the first and second intervention seasons respectively. Also, the design training program in this study was represented the typical time period that soccer players would be exposed to during pre-season preparatory training. This bring about the potential improvement for the neuromuscular control and sensorimotor performance in and around knee joint which increase the accuracy and the efficiency which in turn increase the sensitivity to pick up any significant changes of performance by athletes. This sensitivity is based on sensory awareness in the form of both feed-back and feed-forward is a key aspect in protecting the integrity of the knee joint. Feed-forward neuromuscular control involves planning movements based on sensory information from past experiences via a pre-activated muscle tension (preparation for anticipated loads or activities), whereas the feed-back process continually regulates motor control through reflex pathways, helping to maintain posture and the regulation of slow movement (reactive muscle activity) (Lephart and FU (2000); besides, it has been suggested that exercises that are proposed to train proprioceptive abilities in the given joint is focus on the individual attention to cues from the brain and autonomous control centers which eventually develops performance (Ashton-Miller et al., 2001). Therefore, the proprioception training can be recommended without limitations as a helpful instrument for injury prevention and movement coordination during sport activities (Bruhn et al., 2001).

Thus, a suitable neuromuscular training program may be an effective method to speed up (i.e. shorten) the reaction time during sport activities to prevent serious injuries among athletes. The effect and duration of reaction time with regard to proprioception training has received very limited concern. Therefore, more research is needed to speed up the reaction time as the outcome of proprioception training program to prevent knee joint injuries and subsequently ACL among athletes.

Conclusion and future direction

The present study was conducted to evaluate the effect of proprioception training program on the knee joint position sense in male soccer athletes. Joint position sense was evaluated in both dominant and non-dominant limb prior to and after 6 weeks training program. The results of this study indicated that a proprioception training program provides sufficient evidence to support an improvement in joint position sense after the training intervention. Therefore, this type of training intervention is so important to prevent injuries among male athletes whom may place themselves at greater risk of injuries during sports activities due to a low level of neuromuscular conditioning and sensorimotor awareness. Furthermore, the current training program may also applicable to either sports injury rehabilitation programs or right after surgical intervention where the greater.

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