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The Effect of Short-Term Usage of Rigid Neoprene Knee Sleeve and Soft Neoprene Knee Sleeve on Knee Joint Position Sense Perception after Reconstruction Surgery of Anterior Cruciate Ligament

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Abstract: The aim of the present study is to compare the effect of Neoprene Knee Stabilizer and Neoprene Knee Support on knee joint position sense of patients who had a reconstruction surgery on their anterior cruciate ligament. The joint position sense was measured through the method of active reproduction trial of target angle in open kinetic chain. The target angles for knee joint flexion were set at 30, 45 and 60. 11 male patients (with average age 30.8±4.6 and average weight 75±9) were tested in three stages: 1) immediately after reconstruction surgery of anterior cruciate ligament (BPTB method) and before using knee stabilizer, 2) thirty minutes after using knee stabilizer and 3) after putting off the knee stabilizer. These three trials were conducted in 3 positions with Neoprene Knee Stabilizer and Neoprene Knee Support and in 24-hours intervals. The averages of absolute-error of target angle reproduction were statistically analyzed after 5 times of trial repetition. Statistics shows that using Neoprene Knee Stabilizer in 30° angle has a meaningful, positive effect on knee joint position sense ($p<0.05$). This improvement of joint position sense was lost after putting off Neoprene Knee Stabilizer.

Key words: Neoprene knee sleeve % Joint position sense and reconstruction of knee anterior cruciate ligament

INTRODUCTION

The knee joint is one of the most important parts of kinetic chain of limb. This joint has mainly been designed for endurance against weight and movement and is instable, especially in internal-external direction [1-3]. Since this joint located between two long Tibia and Femur and there is no skeletal stability there, several external forces press the soft texture. For this reason, the joint is significantly dependent on muscles and ligaments. The Anterior Cruciate Ligament (ACL) is one of the most important knee ligaments [1-3]. ACL has a mechanical function to stabilize knee and also make a significant neurological feedback. These feedbacks along with information sent by skin, capsules, tendon, muscles lead muscles to react through Muscle Spindle System in order to control knee joint dynamic [4, 5]. It also improves joint position sense perception and kinesthesia and, as a result, knee proprioception. Proprioception makes reflexes which stabilize the organ and support it against extra movements [5-7].

Unfortunately, ACL is the most vulnerable ligament to injuries [8]. ACL tear not only lead to mechanical disorder of the knee, but also makes some disorders in knee proprioception; because it can not receive the sensory-environmental message by its receivers [6]. Partial de-afferentation leads to some changes in reflex routs of skeletal muscles, muscle spindle and upper centers [6]. In sum, A.C.L tear decrease mechanical stability of knee, knee sensory-motor harmony, capability of joint dynamic control system and joint position sense perception. The joint instability results in continual and degenerative injuries that have negative effect on sporting and daily-life activities.

It shows the importance of A.C.L reconstruction [8]. New A.C.L reconstruction methods make more stability in the joint [8, 9]. Researches, however, indicate that A.C.L reconstruction improve knee joint proprioception. Also,

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Bonfim *et al*. [8] studies showed that functional recovery, in several cases, is not improved completely after A.C.L reconstruction.

According to Bonfim *et al*. [8], the reason is the deficiency of knee joint proprioception [8].

Using some supporting tools such as brace, neoprene knee sleeve and elastic bandage support the knee against sudden strokes, warm the knee up, increasing confidence and convenience of the patient and also make the knee joint mechanically stable. Moreover, stimulating touches and pressure receptors of skin, muscles and capsule, they improve knee joint proprioception and therefore functional stability. Birmingham *et al*. [10] report that about 55% of orthopedists prescribe all of their patients to use brace or knee sleeve to support graft after A.C.L reconstruction. Regarding widespread usage of knee supporting tools after surgery and varied press brace and knee sleeve with different substance, shape and solidity (soft or rigid), it is realized that it is very important to study different functions of these supporting tools on neuromuscular system [10].

According to Beynnon *et al*. [6], there is now agreement between researchers about the role of knee supporting tools such as brace, knee sleeve and bandage in improving proprioception in person who had an A.C.L reconstruction. Therefore, the present research conducted to examine the immediate effect of soft and rigid neoprene knee sleeve on proprioception improvement in person who had an A.C.L reconstruction, providing an equal study condition regarding participants, type and time of injury, measurement method and controlled and same physiotherapy for patients. Finding the most appropriate knee sleeve which improves the joint position sense and, therefore, proprioception especially for mentioned participants helps the patient to prevent an unsuccessful surgery, return to daily life and professional sporting activities and do not waste his/her money and time.

MATERIALS AND METHODS

In this quasi-experimental research, 11 subjects who had an A.C.L reconstruction were studied in one group. Convenience sampling method was used to choose subjects.

The necessary inclusive criteria to be included in the study were as follows:

Fig. 1: Neoprene Knee Stabilizer and Neoprene Knee Support

- Having A.C.L reconstruction in Bone Patellar Tendon Bone method performed by a knee Orthopedist surgeon.
- Age between 20 to 40 years old
- Mental and memory health
- Muscular-skeletal health and balance

The exclusive factors which prevent individuals to participate the trial are as follows:

- Hard injury such as meniscus, muscles tendon, joint capsule or ligament tear which should be reconstructed and operated by the surgeon. 2- Joint fracture 3- Any other A.C.L reconstruction in another methods 4- Referring after a 3 weeks interval.

Two Neoprene Knee Stabilizer (rigid) and Neoprene Knee Support (soft) with Oppo[1] brand were used in this research (Fig. 1).

To evaluate and test the knee position sense, an electro-goniometer with 0.1° accuracy was used. Before starting main trials, individuals participated in 30 sessions of physiological treatment with an equal protocol and achieved trial qualifications. Afterwards, they participate in the main trial. Necessary qualifications to participate in the trial were as follows:

- Ability to have, at least, a 100 grade knee flexion without any pain 2- Ability to perform Active knee Ext without any pain 3- No swell or unnatural pain in the knee

Knee Position Sense Trial Method: In the 1st day of trial and after recognition of the under-trial position according to schedule of random steps of trial, a certain knee sleeve was used for the participant and position sense was investigated in three positions: before using knee sleeve, during usage (30 min. after putting on) and immediately after putting it off [11]. In the 2nd and 3rd day of trial,

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positions with and without knee sleeve in the same order as a control (trial during and 30 min. after knee sleeve usage removed) [12]. First, participants learned how trails are performed. When they were ready, the main trials performed [13]. For knee position sense trial, first of all the participant sit on the chair. The back of chair was set at 80° toward horizon (to back) [13]. To put the thighbone in a more horizontal position, two special pads were placed under two legs next to knees, so that stalks placed vertically on the ground and make a 90° angle with legs. After calibrating the goniometer and setting 0° and 90°, the immovable hand of the goniometer was adjusted to thighbone, its movable hand to stalk-bone and its mechanical rounding axis to anatomic movement axis of knee. To make the patient aware of how the trial is performed, it was performed in a pilot manner, with open eyes and in arbitrary angles two or three times [8, 11, 13, 14]. Afterwards, according to the schedule of trial stages, the first target angle set randomly was introduced to the patient with close eyes before using any knee sleeve [10]. The patient's stalk was held at this angle for 5 seconds [10, 11, 15]. Then, the patient's leg was set back to the first 90° position and was held for 5 seconds [10, 14]. Next, the patient was requested to reconstruct the target angle by active knee Ext in open kinetic chain. The researcher recorded the degree of reconstructed angle. This trial repeated for 5 times and the absolute-error in reconstructing the target angle was calculated and recorded. In line with schedule of the trial, position sense was experimented in the same way and at other angles with 30 seconds intervals. All of these stages were repeated 30 min. after using the knee sleeve and immediately after putting it off. So, the 2nd and 3rd day trials were performed.

FINDINGS AND RESULTS

In Table 1, the descriptive indexes of participants' anthropometric specifications are shown. Athletic activity level variable (professional athletes= 4, semiprofessional= 3, amateur= 2 and non-athlete= 1) shows that participants can be considered as amateur in regard of activity level.

Table 2 indicates central tendency and dispersion of trialed variables for any variable in 24 positions. In this table, control trials without knee sleeve, soft neoprene knee sleeve and rigid neoprene knee sleeve are summarized as Control, Soft and Rigid. Table 2 represents results of all trials in three positions of before, during of and after using knee sleeve at three 30, 45 and 60 position.

Table 1: Statistical indexes of measured variables

Variable	M	DS
Age (years old)	30.80	±4.64
Height (cm)	177.70	±6.34
Weight (kg)	75.10	±9.28
Athletic Activity Level	2.27	±0.64

Reconstruction absolute-error of target angle improvement percentage

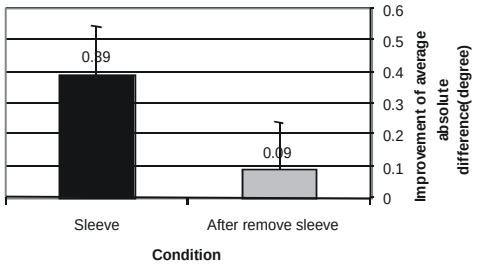

Fig. 2: Average of reproduction absolute-error of 30° angle improvement degree in trials during of and after using rigid neoprene (0.39=during use & 0.90=after use)

Reconstruction absolute-error of target angle improvement percentage

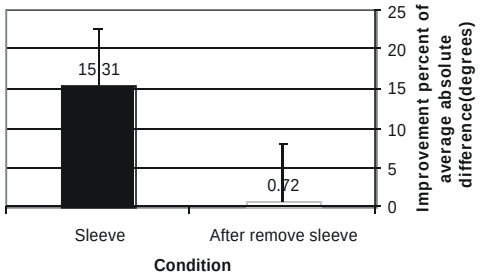

Fig. 3: verage of reproduction absolute-error of 30° angle during of and after using rigid neoprene (15.31=during use & 0.72=after use)

Statistical analysis of results showed that there is no significant different between absolute-error for active reproduction of 30°, 45° and 60° before, during and after using the soft neoprene knee sleeve. Joint position sense trials with rigid neoprene at 45° and 60° show the same results. However, in study using one-way repeated measurement ANOVA and one-sample t-test on improvement degree (Fig. 2) and also normalized values in the form of improvement percentage (Fig. 3), it was realized that there is a significant different between

Table 2: Central tendency and dispersion of trialed variables calculated from absolute-error of target angle reproduction in different trials

Trial	M	SD	Trial	M	SD
Control, 30, before	1.92	0.61	Soft, 60, before	2.04	0.65
Control, 30, after	1.92	0.70	Soft, 60, during	1.95	0.84
Control, 45, before	1.45	0.22	Soft, 60, after	1.99	0.47
Control, 45, after	1.46	0.53	Rigid, 30, before	2.11	0.66
Control, 60, before	1.86	0.39	Rigid, 30, during	1.71	0.37
Control, 60, after	1.79	0.34	Rigid, 30, after	2.02	0.74
Soft, 30, before	1.82	0.62	Rigid, 45, before	2.15	0.75
Soft, 30, during	1.43	0.57	Rigid, 45, during	1.55	0.68
Soft, 30, after	2.26	0.99	Rigid, 45, after	1.91	1.16
Soft, 45, before	1.80	0.39	Rigid, 60, before	1.71	0.49
Soft, 45, during	1.83	0.50	Rigid, 60, during	1.34	0.55
Soft, 45, after	1.54	0.87	Rigid, 60, after	1.45	0.62

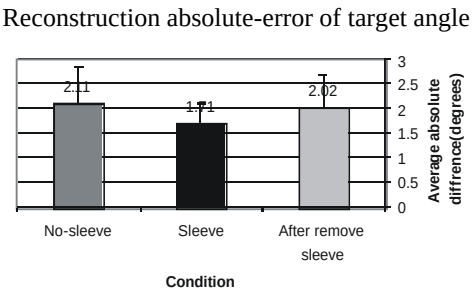

Fig. 4: eproduction absolute-error of 30° angle improvement percentage during and after using rigid neoprene (2.11=before use, 1.71=during use & 2.02=after use)

reproduction absolute-error of 30° angle in trials during using rigid neoprene in comparison with trials before and after using this kind of neoprene (Fig. 4).

In fact, using rigid neoprene leads to a significant improvement in the knee joint position sense at 30° flexion of knee. Therefore, using rigid neoprene (knee stabilizer) at 30° flexion of the knee, results in knee joint position sense improvement in amateur athletes who reconstructed the A.C.L.; also, putting it off removes the effect.

DISCUSSION AND CONCLUSION

Proprioception information is gathered at least from three sources: joint mechanoreceptors, muscle spindles, touch and pressure receptors of the skin. It seems that muscle spindles have an important role in intelligent comprehension of organs movements [12, 15]. Co-activation of fusimotor nerves (*) provokes ascending activity of muscle spindles. Central nerves system needs fusimotor nerves activity (in subtract or sub-cortical level) to make a more precise proprioception [12]. It has been suggested that other mechanoreceptors existing in joint and skin can affect fusimotor nerves and make more changes in ascending muscle spindles. Therefore, receptors which send ascending messages and exit in skin, ACL and joint capsule increase proprioception inputs [16]. Knee sleeve can make more skin stimulus and compensate deficiency of proprioceptive messages directly (making more sensory-organic) or indirectly (in a reflective manner through proprioception routs) through muscle spindle or reflective proprioception routs; this process results in joint position sense improvement [10, 12]. Elastic and compressive knee sleeves moving on the skin lead to provoke different receptors. Receptors which receive the most stimuli are surface receptors with immediately adjustment such as free nerve endings, hair end organs, Merkel's discs and Meissner's corpuscle which are located under skin and muscular layers. These receptors response immediately to new stimuli such as knee sleeve movement on the skin and adjust immediately as soon as the movement is rhythmic. The pressure of elastic knee sleeves affects receptors existing under deeper layers of skin or joint capsules such as ruffini corpuscle. These receptors are tunics with slow adjustment and can provide proprioception inputs in moving or stability mode after they receive stimuli form bandage or knee sleeve; but they receive less stimuli in comparison with surface receptors. In a theoretical viewpoint, improving and enforcing ascending stimuli by bandage or elastic knee sleeves can help proprioception system of people. Of course, it is obvious that putting off the knee sleeve and as a result disconnecting stimuli made through skin or under skin by the neoprene knee sleeve, effects created by these stimuli are omitted. As Hassan BS & Perlau concluded in their research, in practice, this theory is approved for people who have a weak joint position sense. But it is not obvious that it has any effect and benefit for people who have a strong joint position sense [11, 16]. So, people who have some disorders in their proprioception, for example in arthritis or ACL tear, it can be expected to make a significant improvement in proprioception using knee sleeve or bandage.

The Effect of Type of Knee Sleeve on Knee Joint Position Sense: The present study concluded that only the rigid neoprene (at 30°) can significantly improve knee joint position sense in people who had an ACL reconstruction and the soft neoprene has no significant effect on knee joint position sense in that angle. To justify the reason of positive effect of rigid neoprene knee sleeve in improving knee joint position sense (30°) in participants and also ineffectiveness of soft neoprene knee sleeve at the same degree using existing theory about how knee sleeves affect proprioception. In knee sleeve affecting mechanism, it was mentioned that stimulus of proprioception receptors by neoprene knee sleeve increases proprioception inputs and as a result proprioception. So, only knee sleeves which make an appropriate stimulus or more effective pressure on the skin or under layers can improve proprioception.

In the present study it was observed that because of this reason, soft neoprene knee sleeve could not have any effect on improving knee joint position sense. Rigid neoprene knee sleeve, however, because of more straps up and down of the knee and two metallic joints in both sides of the knee, can improve knee position sense at 30° angle. Other reason for ineffectiveness of soft neoprene at three studied angles and/or rigid neoprene at 45° and 60° is that most of proprioceptive receptors existing in the joint capsules and ligaments such as free nerve endings and stretch receptors of Golgi tendon organ are very deep and so, they can not be provoked by bandages and knee sleeves. This effect leads supporting tools to be limited in improving proprioception [16]. This is more applied to the soft neoprene which makes less pressure on the skin and under layers. Beynnon *et al*. [6] and Birmingham *et al*. [12] approve this idea [6, 10]. Therefore neoprene knee sleeves can not compensate proprioceptive messages through muscle spindles or reflexive routs of proprioception. However, as it was realized for rigid neoprene knee sleeves (at 30° angle), a well-designed knee sleeve and appropriate stimuli on skin and under skin receptors can improve proprioception. Studying comparative results of knee position improvement at 30° angle after using soft and rigid neoprene knee sleeves approve that the type of knee sleeve is more important than the degree of angle. Although this angle (30°) may have some effects on proprioception, it seems that, despite of these effects, the soft neoprene knee sleeve has a weaker performance in comparison with the rigid one.

The Effect of the Angle on Joint Position Sense: The present research showed that the rigid neoprene knee sleeve can improve joint position sense just at 30° angle. The affecting of angle on joint position sense mechanism can be explained as follows: proprioception is more depended on receptors existing in muscle and joint. Muscular receptors have a more significant role, especially, during active movements. When muscles are stretched in movement cycles, firing rate of muscles spindles are more than when muscles are short. This is called hysteresis phenomenon which is used in movement control and have a close relation with joint position sense accuracy and awareness of joints inaction position [17]. Co-activation of fusimotor nerves (*****) increases ascending action of muscle spindles and muscles which simultaneously jerk, increase proprioception accuracy by increasing sensitivity to stretching in activated muscle spindles around the joint [7]. It happens extremely at 30° angles in which vastus medialis action and hamstring muscles elongation is more than 45° and 60° angles and more elongation of capsule and ligament on the extension terminal limit than centric limit leads to provoke different receptors which can increase awareness of proprioception. It is compatible with this idea that proprioception has a more important role in knee stability, especially on terminal extension terminal limit [12, 13, 17].

On the other hand, the static stability of knee joint on the initial flexion of the joint is more than other angle. The reason is that there are more contacts between femur and tibia and ligaments are more rigid in the contact area. Messages initiated from muscular-tendon mechanoreceptors are integrated with information sent by skin, under skin, capsules and ligaments to make proprioception more precise, whereas static stability of knee joint is weaker on central limit (45°- 60°); because all of its ligaments are in loose mode and the activity of vastus medialis muscle is increased. Increasing the angle toward knee joint flexion alongside sending messages initiated from muscular receptors, increasing proprioception information sent by different receptors and movement control system need to process bulk of information and activate more muscular groups make some disorders in proprioception of this joint. Because in this case, it leads to higher fidelity kinesthetic image and the knee sleeve increases inputs. As a result, proprioception system is satiated [12, 13]. Therefore, it is expected that these rigid or soft knee sleeves at 45° or 60° angle make no significant improvement in proprioception of participants and make a better improvement at the 30° angle. It was observed that rigid neoprene improved knee joint position significantly at the 30° angle. This finding approves Weiler *et al*. [17], Pincivero *et al*. [18] and Fremery *et al*. [19] findings [13, 17, 18]. Moreover,

according to Proske [19], weight force torque can help the knee joint position sense, too. This torque is maximal at the terminal extension angle of the knee [19].

Since the present research shows that using rigid neoprene knee sleeve at the 30° angle improve the knee joint position sense in person who had an ACL reconstruction, it is suggested to use rigid neoprene during exercises to increase proprioception at that angle, confidence, stability and to decrease swells. Pincivero *et al*. [18] believe that whereas the flexion angle of knee was considered as 45° in most of measurements, it is functionally of less importance in real life and only is a medial position through walking. Since exercises for reinforcement and jerk of terminal movement extension of the knee is advised because of joint rigidness and muscle weakness after surgery in this area, it become obvious that using rigid neoprene (Neoprene knee stabilizer) is very important. It may be used for other patients suffered from proprioception disorder during exercises. It should be mentioned that using knee sleeves for a long time is not suggested, unless during exercises; because it may weaken muscles.

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