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Effect of bracing on the prevention of anterior knee pain – a prospective randomized study

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Abstract There have been numerous reports about the use of knee braces to prevent traumatic knee injuries. Despite the frequent use of braces, very few prospective studies have been performed to study the effect of knee braces for preventing anterior knee pain syndrome (AKPS). The purpose of this study was to assess the effectiveness of a dynamic patellofemoral brace (On-Track System, dj Orthopedics) in the prevention of AKPS. 167 military recruits without history of knee pain were randomized into two groups prior to the start of their 6-week basic military training (BMT) program. The first group (brace group) consisted of 54 recruits who wore the braces for all physical activities during these 6 weeks. 113 recruits served as a control group, and followed the same 6-week strenuous training program. Chi square statistics (Fisher exact test) were used to compare the number of AKPS patients in the brace group and in the non-brace group. Our results indicated that recruits in the brace group appeared to develop significantly less anterior knee pain compared to the recruits in the control group (p =0.020). Out of the 54 recruits in the brace group, ten (18.5%) developed anterior knee pain during this study. In the control group (n =113), 42 recruits (37%) developed anterior knee pain. We conclude that the result of the present study suggests that the use of a dynamic patellofemoral brace is an effective way to prevent the development of anterior knee pain in persons undergoing a strenuous training program.

Keywords Patellofemoral pain · Orthosis · Treatment · Patellofemoral joint

Introduction

Anterior knee pain syndrome (AKPS) is a very common and intriguing condition encountered in the young physically-active and military population undergoing strenuous physical training [1, 4, 9, 19, 21, 24, 27, 28, 40].

The high incidence of AKPS in recruits [27, 28] leads to a considerable loss of training and manpower hours, besides the suffering of the patients [19]. This high incidence of AKPS during this strenuous training is due to the temporary overexertion and the symptoms do often disappear when the training intensity diminishes.

Although the exact etiology of AKPS is not fully understood, malalignment of the patella and lower limb [13, 14] is widely accepted as an important etiological factor of AKPS. Various authors have attributed this pain to intrinsic and extrinsic risk factors [10, 16, 26, 40, 44]. Extrinsic risk factors are related to factors outside the human body such as the type of sports activity, the manner in which sport is practiced, the environmental conditions, and the equipment used. [20, 32]. Intrinsic risk factors relate more to individual physical characteristics and psychological traits. General agreement exists on the classification of the risk factors of patellofemoral pain syndrome (PFPS) into these two categories.

Numerous reports exist on the therapeutic interventions associated with the use of braces as a conservative treatment for AKPS [1, 5, 12, 16, 29, 31, 36, 37, 38, 41]. The function of those braces is to improve the patellar tracking and maintain the patellofemoral alignment by stretching thigh lateral structures (lateral retinaculum). Besides this mechanical function, some authors suggest other mechanisms (thermal effect, an increased sensory feedback, an altered circulation of the knee region) by which the brace may be effective [8]. Preventive patellofemoral bracing may be viewed as a method to help maintain an "ideal" biomechanical environment in order to avoid irritation of the surrounding tissues.

To our knowledge, only one prospective study has been published on the effectiveness of braces in the prevention of anterior knee pain [2]. Therefore, the goal of our study was to prospectively investigate the effectiveness of a neoprene dynamic patellofemoral brace (On-Track System, dj Orthopedics) on the prevention of AKPS during basic military training (BMT) of officer cadets of the Belgian Royal Military Academy.

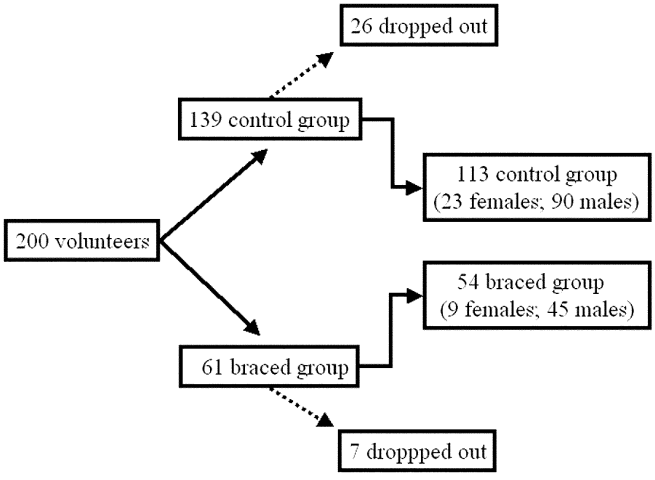

Fig. 1 61 out of 200 volunteers formed the braced group; the others were the control group. 7 and 26 recruits dropped respectively out of the braced and control group during the basic military training for reasons mentioned in Table 1

Table 1 An overview of the dropout reasons for the braced group and the control group. The stress fractures and other traumatic lesions were encountered during basic military training (BMT). The pre-existing lesions were noticed during the evaluation of the volunteers before the BMT

Reason	Brace group	Control group	Total
Quitting the academy	2	6	8
Stress fracture	1	4	5
Other traumatic lesion	1	7	8
Pre-existing lesion	1	2	3
Not participating in all physical training	2	7	9
Total	7	26	33

Materials and methods

Subjects

Two hundred officer cadets volunteered for the study (Fig 1). Thirty three of the 200 officer cadets dropped out due to different reasons described in Table 1. Therefore, 167 persons (32 females, 135 males) participated in the study. Fifty four volunteers (45 males, 9 females) were randomized to the experimental group, and 113 (90 males, 23 females) served as controls. Table 2 shows the anthropometrical data of all subjects.

Approval of the Ethics Committee of the Belgian Department of Defense was obtained before commencement of the study. Each participant signed an informed consent and knew the goals of the study.

Equipment

The On-Track (DJ-Orthopedics) dynamic patellofemoral brace was used in this study. This brace consists of knee patches with Velcro (VELCRO USA Inc., Manchester, NH) and a neoprene sleeve (Fig. 2). The design of the brace is based on the correction of the position of the patella as described by McConnell [24]. The little plastic button (activator) foreseen to stimulate the vastus medialis obliquus (VMO) muscle was not used in this study.

Basic military training (BMT)

All 167 cadets in this study followed the same 6-week BMT during the same period (September-October). This BMT mainly consists of running, roadwork, military tactical exercises, drill, shooting, marching with backpacks and some theoretical classes. Since all recruits had the same training program, equipment, environmental conditions, food, and daily schedule, we believe the extrinsic contributing factors which could affect the incidence of AKPS were kept mainly under control in this study.

Prior to the start of the BMT, the same military physician, who was also informed on the medical history of the cadets, assessed the knees of all subjects for signs of ligamentous instability, meniscal abnormalities, effusion or tenderness. All subjects with a history of knee complaints were excluded from the study. Each subject was braced bilaterally.

Each subject was individually instructed by an experienced physical therapist (first author) how to put on the two dynamic patellofemoral braces properly. During the whole BMT the same physical therapist skilled in the McConnell taping method [24, 39] and bracing technique was present. All subjects could therefore

Table 2 Anthropometrical data for both groups: the "*Brace group*" is the experimental group. *BW* body weight, *BMI* body mass index. No significant differences were found between the groups

	Brace group			Control group		
	Mean	SD	Range	Mean	SD	Range
Age (years)	18.9	1.3	17–23	19.3	1.6	17–26
Length (cm)	180.3	6.9	163–198	177.8	7.9	158–194
BW (kg)	71.7	8.9	54–100	68.8	9.5	49–105
BMI	22.0	2.1	18.3–28.6	21.8	2.5	17.2–31.0

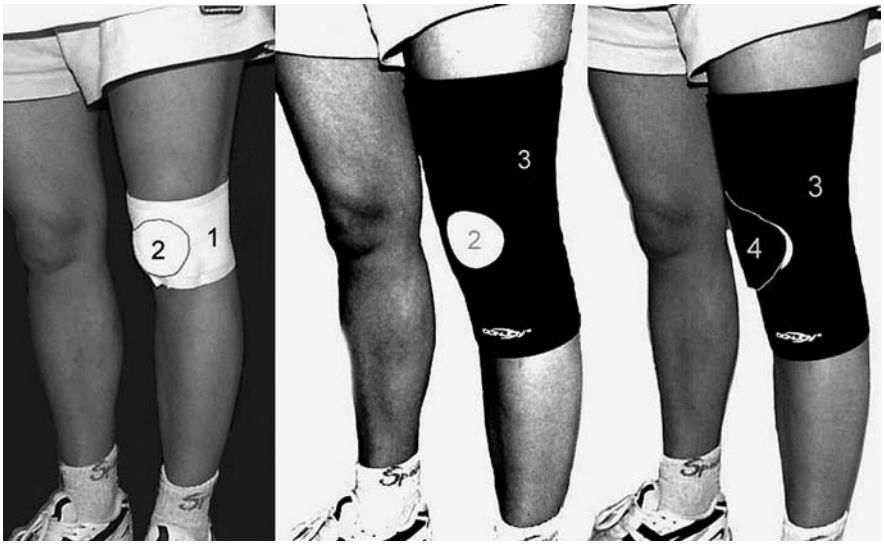

Fig. 2 The On-Track brace (DonJoy) in 3 parts. A self-adhesive patch (*1*) is applied on the knee with the loop circle (*2*) on the patella. The neoprene cuff (*3*) is pulled onto the leg so the loop circle shows through the opening of the cuff. The hook circle (*4*) is attached to the loop circle on the patch

reach him at any time during BMT if they had trouble or questions concerning the braces. All recruits in the brace group were informed to wear the braces during all physical activities, such as running, road marching, tactical exercises, drill and shooting. They were asked not to wear them during rest periods. An experienced military physician diagnosed all anterior knee pain syndromes during the BMT.

To be eligible as a patellofemoral patient, subjects had to have a characteristic history and symptoms of anterior knee pain syndrome (that is, retropatellar pain during physical activities such as jumping, running, squatting, and going up or down stairs), exhibit two of the following clinical criteria on assessment [35, 43] – pain on direct compression of the patella against the femoral condyles with the knee in full extension, tenderness on palpation of the posterior surface of the patella, pain on resisted knee extension, and pain with isometric quadriceps contraction against suprapatellar resistance with the knee in 15° of flexion – and negative findings in the examination of knee ligaments, menisci, bursae, synovial plicae, Hoffa's fat pad, iliotibial band, and the hamstring, quadriceps, and patella tendons and their insertions.

Statistical analysis

The SPSS software (version 10.1) package was used for statistical analyses. Chi square statistics (Fisher exact test) were used to compare the number of AKPS patients in the experimental group and in the control group (p <0.05). Significance was accepted at the 0.05 level.

Table 3 Number of recruits developing anterior knee pain during basic military training

	Anterior knee pain	Total	%
Brace group	10	54	18.5
Control group	42	113	37

Results

A smaller number of recruits in the brace group appeared to develop anterior knee pain compared to the recruits in the control group (p =0.020) (Table 3). Out of the 54 recruits in the brace group, ten (18.5%) developed anterior knee pain during this study. In the control group (n =113) 42 recruits (37%) developed anterior knee pain.

Discussion

Besides the use of bracing as a treatment of AKPS, it has been assumed to be helpful in the prevention of AKPS [31]. However, few studies have scientifically studied this effect. We evaluated the effectiveness of a preventive knee brace assumed prophylactic on the incidence of AKPS in military recruits. Our results suggest the usefulness of

patellofemoral bracing as a preventive measure. Since the knees of the braced recruits had to be shaven to wear the knee brace in a proper way (Fig. 2), the outcome assessor (military physician) could not be blinded to the study group. This must be acknowledged as a limitation of the study. In this study, we used the proposed diagnostic criteria [35, 43] and did not bring the VAS into account. This could be another limitation of our study, since the symptoms of AKPS could be leveled from mild to severe. But our results are in agreement with the results of BenGal et al. [2] although we used another type of brace. BenGal et al. [2] studied the efficacy of the knee brace with supportive ring as a means of preventing AKPS in 60 young athletes. They found a significant reduction in the incidence of AKPS at the end of the study in the braced group compared to the control group.

Hence, the results of both studies seem to scientifically support the effectiveness of a knee brace in the prevention of AKPS. Nonetheless, the mechanism by which bracing seems to influence on the prevention or the treatment of AKPS remains enigmatic [35]. In the literature, a pure mechanical mechanism [33, 36], an alteration in proprioception [3, 25, 34] and an altered muscular recruitment are proposed [15, 17, 22, 30, 33].

It remains questionable whether a prophylactic knee sleeve has a direct mechanical influence on the tracking of the patella on the femoral condyles. Powers [35] hypothesized that the use of external supports causes a change in the contact area between the patella and trochlea, by seating the patella deeper into the trochlear groove. In contrast, Bockrath et al. [6] showed no significant modification of the patella between the femoral condyles after taping. The few existing studies on the influence of patellofemoral braces on the position of the patella show contradictory results [29, 38]. Interestingly, in our study we did not try to modify the position of the patella, but tried to stabilize the "ideal" position of the subject's patellae while they were all painless at the beginning of the BMT. Whether we achieved this goal in this study, and as a result found a significantly smaller number of recruits with AKPS in the brace group compared to the control group, remains unclear.

In addition to a possible mechanical effect, it has been shown that wearing a knee brace has significant consequences on the proprioceptive capacity [3, 25, 38]. Birmingham et al. [3] studied the effect of wearing a neoprene knee sleeve during active and passive movements in open and closed kinetic chains. A significant improvement of proprioception, in the braced condition, was found during angle reproduction. Perlau et al. [34] found the same results in an open kinetic chain setting with an elastic knee sleeve. On the base of these results it is tempting to state that the military recruits in the brace group had a better proprioceptive input during BMT compared to the control group. Since it has been shown that good proprioception leads to a decrease in injury rate, the results of this study seem to match with this [7, 18].

Consequently, by wearing a knee brace during this training program, a possible improvement in proprioception could theoretically play a significant role in the observed reduction of AKPS in the brace group.

Finally, Osternig et al. [30] and Gilleard et al. [15] suggest that bracing alters the recruitment patterns of the surrounding muscles. Gilleard et al. [15] found a changed activation timing of the vastus medialis obliquus (VMO) and vastus lateralis (VL) muscles in patellofemoral patients by applying a patellofemoral taping described by McConnell [24]. Werner et al. [42] found in patients with patellofemoral pain and patellar hypermobility that taping improved the knee extensor torque. Ernst et al. [11] reported an increase in knee extensor moment and power with patellar taping during lateral step-up and vertical jump. However, clinically this did not lead to greater vertical jump height. In the study by Lysholm et al. [23] 88% of the patellofemoral pain patients improved their isokinetic performances when a brace was used.

Osternig and Robertson [30] measured the joint position and EMG activity of nine muscles during braced and non-braced conditions. They used a single-sized prophylactic knee brace (Protective Knee Guard, Smith & Nephew Donjoy Inc., Carlsbad, CA) designed to prevent valgus stress of the knee. They observed a significant modification of the joint position pattern at fast (3.81m/s) and slow (3.33m/s) running speeds during the braced condition versus non-braced condition for all nine subjects. They also observed that the vastus lateralis, vastus medialis, biceps femoris, semimembranosus and tibialis anterior showed significantly smaller EMG activity during the braced versus the non-braced condition. Furthermore, Gulling et al. [17] noted a significantly smaller IEMG signal of the VMO and VL during braced isokinetic activity comparing to a non-braced condition. By correcting the patella's anterior-posterior tilt [22] or lateral glide [33] with tape in asymptomatic subjects, an altered onset of the VMO and VL during a functional task (stair ascent) has been found.

All those data suggest that lower-extremity neuromuscular control is altered when external devices are applied. These studies show that alterations by applying a brace or tape are not pain-related. The combination of the potential anchoring effect of the tape or brace and its anatomical stabilization may reduce the need for muscle activity [15, 33]. This could influence the tracking of the patella and consequently the appearance of AKPS in subjects with a poor patellar tracking who are brutally subjected to a strenuous training program.

It is probable that a combination of the three abovementioned mechanisms (mechanic, proprioceptive and muscular recruitment pattern) is responsible for the observed decreased incidence of AKPS in military recruits wearing a brace during BMT in the present study. We didn't use any sham brace in order to measure the real impact of the brace. We are also aware of the study conducted by Finestone et al. [12] and the results obtained by

Perlau et al. [34] with simple knee sleeves. Greenwald et al. [16] observed that the use of patellofemoral braces improves subjectively the knee stability and pain perception in patellofemoral patients, but they could not demonstrate any objective effect. Since all the recruits were informed about the ongoing study during their BMT, and some of them received extra equipment, a placebo effect cannot be excluded.

Conclusions

AKPS is frequently observed as a result of prolonged intensive training. The results of this study suggest that the use of a patellofemoral brace is an effective way to prevent AKPS in subjects undergoing a strenuous training program. This finding is clinically important, since prevention of overuse injuries is in many cases a primary concern, especially during basic military training. The mechanism behind this prophylactic effect of bracing on the patellofemoral joint remains uncertain. There is some evidence that bracing alters proprioception and muscular recruitment, which possibly could explain its positive effects. Other authors focus their research on the mechanical impact, but evidence on this subject is still lacking.

Irrespective of the exact underlying mechanism of this brace, the present study shows its significant preventive effect on the development of AKPS during basic military training. Therefore, the results of this study support the use of prophylactic patellofemoral bracing in subjects undergoing vigorous activities. However, further research is needed to improve our insight in the underlying working mechanisms of prophylactic bracing on AKPS.

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