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The effect of derotation braces on knee motion

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Four different types of derotation braces and an elastic knee support were tested on ice-hockey players. The elastic support did not noticeably affect rotation and abduction-adduction of the knee. All four braces reduced rotation and abduction-adduction in test actions simulating sports situations. Flexion-extension was slightly affected by two of the individually made braces in one action. Running a figure eight was slower with two of the individually made braces. The best braces, one individually made and one ready-made, limited rotation and abduction-adduction effectively, but did not affect performance. Minor differences in design may account for differences in effect and may alter the protection afforded by a brace.

Derotation braces are commonly used to protect and support the knee. Houston and Goemans (1981) claimed that three different derotation braces all reduced strength and performance, which could be a disadvantage especially in prophylactic use.

We have examined the effects on knee motion of four derotation braces and an elastic support brace.

Materials and methods

The investigation consisted of two parts. In Part I, three specially constructed and individually made derotation braces were studied. In Part II the individually made brace that was considered best in Part I was compared with a ready-made brace and an elastic support (Figure 1). The same testing procedure was followed in both parts.

Brace A with three-point fixation was a modified Lenox Hill derotation brace (Nicholas 1983), with lateral supports on the thigh and leg, and with a mobile medial support following the motion of the leg. Two crossed straps behind the knee prevent hyperextension. The weight of this brace is 920 grams.

Brace B resembles brace A, having lateral and medial supports at knee level. The medial support is immobile, does not follow the motion of the knee, and extends forwards to prevent anterior displacement of the tibia. An oblique elastic strap on the leg and the back of the thigh keeps the brace from slipping down. Another elastic strap attached to the lateral thigh support is pulled backwards and upwards around the waist to rotate the limb externally. The weight is 727 grams.

Brace C has medial and lateral longitudinally joined metal bars and an anterior plate on the thigh to distribute the load. Behind the knee, there are two crossed elastic straps to prevent hyperextension. To keep the brace from slipping down, elastic straps encircle the thigh and leg. Its weight is 960 grams. Braces A, B, and C were designed by LIC, Stockholm, Sweden.

Brace D ("ECKO-brace," Orthomedics, Los Angeles, USA) was created to control extension in the knee with injury of the anterior cruciate ligament. The design is based on a three-point fixation system. The device is manufactured in three sizes and can be individually fitted with minor adjustments. It is made of a thermoplastic material and is fixed to the limb with two elastic straps. Behind the knee, there are two crossed straps to prevent hyperextension. The weight of the brace is 510 grams.

The elastic knee support E is made of elasticized cotton with two metal bars stuck into leather

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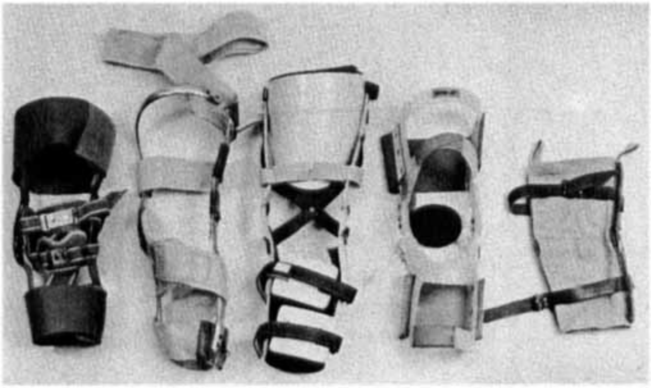

Figure 1

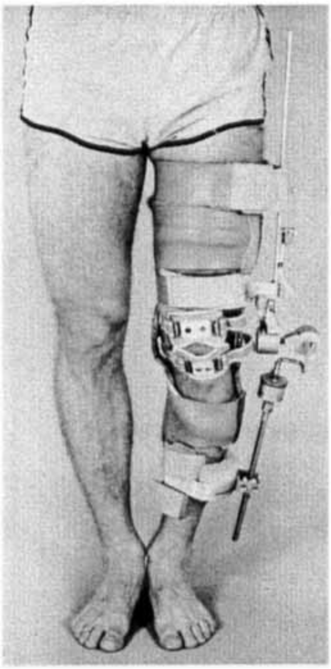

Figure 2

Figure 1. Braces tested. From the left, A, B, C, D, and E.

Figure 2. The goniometer on braced leg.

pockets on each side. It weighs 370 grams. It is manufactured by LIC, Stockholm.

Because the braces had to be individually fitted, we wanted to keep the number of test subjects small. We therefore used a Latin square test design with four replications (Armitage 1983). Seven ice-hockey players with no knee problems were selected, and 1 player participated in both Parts I and II. They were tested with and without each of the four braces at separate sessions and in randomized order spaced at 1-week intervals. The players had previously used each of the braces in training and matches during a 3-week period when all the adjustments were made to obtain an optimal fit.

The electrogoniometer used was, to our specifications, made by SAAB, Linköping, Sweden. It weighs 1.2 kg and has three potentiometers to record extension-flexion, abduction-adduction, and rotation of the leg relative to the thigh (Figure 2). The electrogoniometer was connected to an electrocardiograph (Siemens-Elema, Stockholm, Sweden) for visualization of the different movements (Figure 3). The means of 10 peak values were recorded for each of three different actions: 1) straight walking 6×10 steps, 2) walking 3×3 steps in a figure eight around two cones placed 0.9 meters apart, and 3) skating 3×10 strokes on a slideboard.

Performance with and without a brace was determined in a standardized knee function test (Tegner et al. 1986). Thigh muscle strength with and without a brace was measured with a Cybex-II isokinetic device (Lumex Inc., Bay Shore, New York) at 30° and 180°/sec, and isometrically at 60° of knee flexion. All the men graded the braces on a semantic differential scale (Osgood 1978) four times during the tests.

For statistics, we used the analysis of variance. First, an *F*-test was performed. If it turned out significant on the 5 percent level, *t*-tests between the different braces were carried out. All comparisons reported in this study refer to such *t*-tests; the symbols in the text indicate significance: $^{***}P < 0.001$, $^{**}P < 0.01$, $^{*}P < 0.05$. The reproducibility of the goniometric measurements was determined by applying the goniometer four times on the same subject, who then performed the straight walking test. The coefficient of variation was 18 percent.

Results

Knee movements

In neither Part I nor Part II did the order of application of the braces affect the results. The results were similar for all four repetitions in both test rounds.

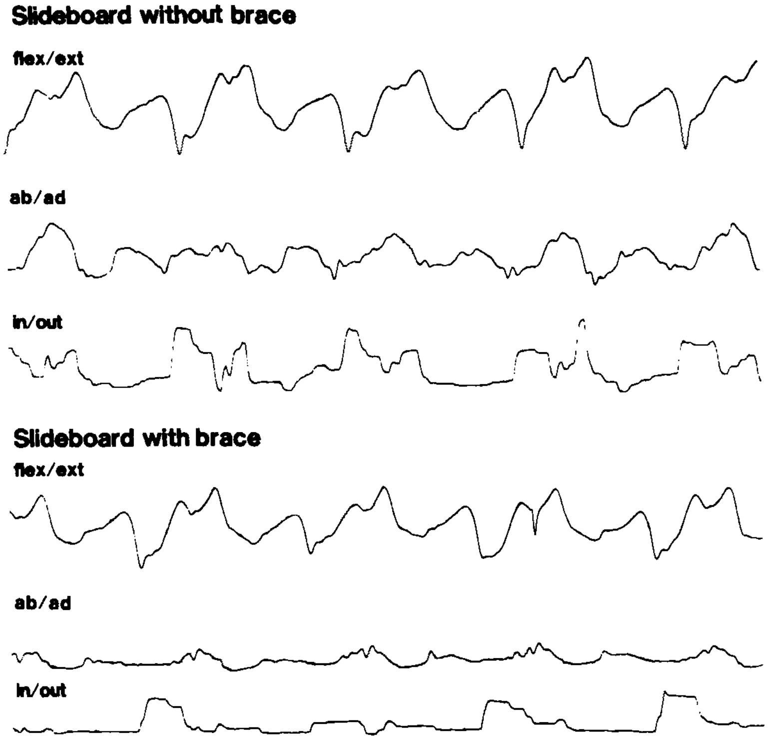

Figure 3. Electrogoniometer curves showing knee motions during slideboard skating. Note the diminished abduction-adduction and rotation with the brace, whereas extension-flexion is largely unaltered.

Part I. None of the braces A, B, or C had any effect in extension-flexion motion when walking straight or on slideboard skating. In the figure-eight walk, braces A and B reduced* extension-flexion, but C did not.

Without a brace, rotation increased*** from 13 ± 6° (mean ± SD) on straight walking to 23 ± 9° on the slideboard and 31 ± 9° in the figure-eight walk (Table 1). All the braces reduced the degree of rotation by up to 70 percent in all the actions. In slideboard skating, brace C reduced** rotation more than did brace A.

Abduction-adduction was increased*** in the slideboard test and the figure-eight walk compared with straight walking. In the slideboard test and the figure-eight walk, all three braces reduced*** abduction-adduction. In straight walking, braces A** and C* reduced abduction-adduction, but brace B did not. In the slideboard test, braces A and C reduced* abduction-adduction more than did brace B. All the braces reduced the amount of abduction-adduction by about 40 percent.

Part II. Brace D (ECKO brace) had no effect on extension-flexion. The elastic support (brace E) reduced* extension-flexion in the figure-eight walk and the slideboard test. Brace A reduced*** extension-flexion in the figure-eight walk.

Table 1. Tibial movements (mean degrees) with the different braces

	A	B	C	D	E	No brace
Cone walking						
Ab/adduction	14	17	15	17	24	25
Rotation	13	13	8	12	31	31
Slideboard						
Ab/adduction	13	17	13	14	24	25
Rotation	14	12	9	15	21	23

Rotation increased*** without the brace in the figure-8 walk and slideboard skating. The degree of reduction in rotation was equivalent to that in the first test round. In all three tests, braces A and D reduced*** rotation, whereas brace E did not.

Abduction-adduction was similarly reduced by braces A and D, except on straight walking, where brace D did not reduce this movement.

Strength measurements and performance test

Marginal reduction of strength was noted in both test parts. In Part I, brace C reduced* quadriceps strength at 180°/s. In Part II, braces D and E reduced*** hamstring strength at 180°. In no other strength measurements was any clear effect noted.

In Part I, running time in the figure-8 was longer* with braces B and C than with brace A, with which the time was similar to that without a brace. No marked differences in straight running time were noted, but running in the figure-eight was slower** with braces B and C than with brace A. In Part II, none of the braces influenced strength or performance. The one-leg hop was unaffected in both test rounds.

Subjective evaluation

In Part I, every participant considered brace A superior to the others. In Part II, braces A and D were judged equivalent.

Discussion

The great variability between different goniometer measurements probably indicates difficulties in application and design of the device. Our device is similar to the one described by Kettlekamp et al. (1970), and our results also seem to be similar to theirs. In spite of the variability, definite effects of the different derotation braces were recorded, whereas the elastic knee support did not reduce rotation and abduction-adduction.

It was thus obvious that derotation braces limit the amount of rotation and abduction-adduction under circumstances simulating sports. Skating was simulated on the slideboard – one of our aims being to design a test for an injury-preventing brace for ice-hockey players. Even though all the braces were shown to be effective, nothing is known about how much force they can resist. This factor will probably ultimately determine their value in terms of injury prevention.

There were minor differences in effect between the braces, probably reflecting differences in design. Brace B seems to have a less ideal design than the others. It was also less liked by the players. The ready-made brace D was as effective as the individually made brace A, which indicates that the more complex design of brace A may be of little benefit. The elastic knee support did not reduce rotation or abduction-adduction, and cannot therefore be used to stabilize the knee.

In the performance tests the running time in the figure eight was affected by braces B and C. With braces A and D, the running time was unaffected, which shows that these braces may be preferable to braces B and C. It has been asserted (Houston and Goemans 1982) that some braces may harm performance by diminishing quadriceps torque and running speed.

Our findings confirm that braces decrease tibial rotation (Knutzen et al 1983). Diminished instability on clinical testing was demonstrated in braced patients by Bassett and Fleming (1983). The dynamic testing described in our study apparently simulates real conditions more closely than do static stability tests. Our findings therefore seem to indicate that derotational braces do in fact have the desired effect, but that brace design is important in order to achieve maximum efficacy.

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