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Letter to editor

Elastic Knee Sleeves Limit Anterior Tibial Translation in Healthy Females

Dear Editor-in-chief

Knee sleeves or braces represent auxiliary tools that have repeatedly been used by athletes, in an attempt to increase knee stability and, thus, reduce the risk of (recurrent) ligamentous injuries. Since ACL injuries typically occur in situations involving either torsion or hyperextension of the knee, it has been speculated that braces might protect the ACL by countering excessive anterior translation of the tibia with respect to the femur (Beynnon et al., 1997). However, the preponderance of *in vivo* studies to test this hypothesis was performed in cohorts of patients suffering from existent ligamentous (Branch et al., 1988; Colville et al., 1986) or other knee injury (Beynnon et al., 1997; Fleming et al., 2000). This complicates the extrapolation of results to healthy subjects. Further, the braces used in these studies were mostly rigid constructs that consisted of either uni- or bilateral hinged bars (Rishiraj et al., 2009). Such braces might hinder performance (Veldhuizen et al., 1991) and would be rejected by the vast majority of healthy athletes. For these reasons, we would like to use this letter to the editor to report the results of our experiments investigating whether a relatively light elastic knee sleeve would limit the degree of anterior tibial translation in computerized arthrometry tests as performed in a sample of non-injured subjects.

We recruited ten female college students (age: 23.4 ± 3.2 yrs, height: 1.68 ± 0.05 m, mass: 59.9 ± 5.5 kg) who were free of acute or previous injury or any form of orthopaedic disease of the knee joints. The anterior displacement of the tibia was measured using the GNRB® computerized arthrometer (GeNouRob, Laval, France). With subjects lying in the supine position, the lower leg was firmly fixed with plastic caps mounted over the ankle joint and patella. An electrical pressure pad then exerted increasing pressure of up to 250 N on the calf, while a motion sensor, which was positioned on the ventral aspect of the shank, just distal of the patella, recorded the anterior displacement of the tibia. Displacements were continuously recorded but only the discrete values coinciding with 50, 100, 150, 200 and 250 N were extracted for statistical analyses. The GNRB® system features a measurement accuracy of 0.1 mm and has been shown to be a valid tool for measurements of anterior knee laxity (Jenny et al., 2013). To control inadvertent coactivation of hamstring muscles, which may bias the results of arthrometry measurements (Steele et al., 1994), the integrated electromyographic (EMG) activity of the biceps femoris and semitendinosus muscle was simultaneously recorded and normalized to additional recordings obtained during maximal voluntary contraction (MVC). These tests confirmed that, during arthrometry measurements, the EMG activities of biceps femoris and semitendinosus muscle were negligible and remained below 3% of MVC levels at all times. To assess measurement reliability, tests were repeated twice under both experimental conditions: first without and then after application of a light elastic knee sleeve (Cellacare Genu, Lohmann & Rauscher, Rengsdorf, Germany). According to the manufacturer's information, this sleeve can be used for a variety of indications including injury prevention.

Test-retest reliability of arthrometry measurements was excellent, as reflected by low typical measurement errors (0.08 mm) and high correlation coefficients ($r = 0.99$, $p < 0.001$). Analysis of results (Figure 1) by factorial ANOVA revealed that the elastic sleeve tested in this

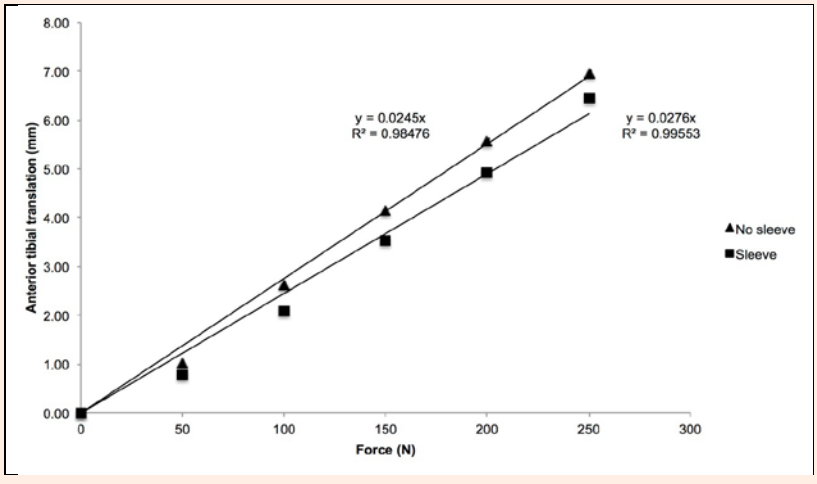

Figure 1. Anterior tibial translation in dependency of the shear force acting on the tibia and usage of an elastic knee sleeve. Note: Displacements coinciding with 50, 100, 150, 200 and 250 N of force were extracted for statistical analysis and fitted by linear regression.

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study reduced the anterior displacement of the tibia by a small (max. 0.7 mm on average) yet statistically significant amount ($F(1,9) = 22.88$, $p = 0.001$, $r = 0.98$). In an attempt to better understand the degree of protection provided by the sleeve, we determined its material properties by appending weight discs (2.5 - 15 kg, in steps of 2.5 kg) to its dorsal aspect and measuring the resulting elongation. The resulting force-elongation relationship was found to be linear ($R^2 = 0.99$), with a slope (i.e., the stiffness of the sleeve) of 2 $N \cdot mm^{-1}$. Thus, at an elongation of 6.5 mm (roughly coinciding with the maximal anterior tibial translation observed in our study), the sleeve would provide a resistive force of ~13 N countering the shear force pushing the tibia anteriorly. However, significant "force × sleeve" interaction effects ($F(0.34,0.09) = 11.53$, $p < 0.001$) also demonstrated that the degree by which the sleeves affected measurement results was dependent on the level of force. With rising force, differences between experimental conditions increased in absolute (from 0.2 to 0.7 mm), yet decreased in relative terms (from 27 to 7%). In this regard, it is important to note that the force exerted on the tibia (max. 250 N) in this study coincides with ACL forces that are well below the range at which ligament tears typically occur. Extrapolation of our data to weight bearing situations, which are characterized by active muscle contraction and significantly greater ACL forces, is complicated so it is not currently clear whether elastic knee sleeves would provide clinically relevant protection to the ACL when subject to excessive loads. In regular movements that induce principally uncritical ACL strains, however, elastic knee sleeves might assist hamstring muscles in countering anterior tibial displacement, thus postponing the onset of muscular fatigue. This hypothesis is subject of ongoing research in our laboratory.

In conclusion, our results demonstrate that usage of an elastic knee sleeve reduces anterior tibial translation in healthy subjects by a small, yet statistically significant amount. Further, the protective effect appeared to be load-dependent, with larger effects seen at greater forces.

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