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Short communication

The effect of leg preference on postural stability in healthy athletes

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ABSTRACT

In research regarding postural stability, leg preference is often tested and controlled for. However, leg preference may vary between tasks. As athletes are a group of interest for postural stability testing, we evaluated the effect of five leg preference tasks categorization (step up, hop, ball kick, balance, pick up) on single-leg postural stability of 16 field hockey athletes. The 'center of pressure speed' was calculated as the primary outcome variable of single-leg postural stability. Secondary variables were 'mean length of the GRF vector in the horizontal plane', 'mean length of the ankle angular velocity vector', and 'mean length of the hip angular velocity vector', as well as the separate outcomes per degree of freedom. Results showed that leg preference was inconsistent between leg preference tasks. Moreover, the primary and secondary variables yielded no significant difference between the preferred and non-preferred legs, regardless of the applied leg preference task categorization ($p > 0.05$). The present findings do not support the usability of leg preference tasks in controlling for bias of postural stability. In conclusion, none of the applied leg preference tasks revealed a significant effect on postural stability in healthy field hockey athletes.

1. Introduction

Diminished postural stability is associated with primary and secondary ankle and knee injuries (Witchalls et al., 2012; Hrysomallis, 2007; Negahban et al., 2013). Single leg stance is the most frequently used method to test postural stability. However, asymmetry in single leg stance postural control that is independent of injury, may reduce the usability of comparisons between the injured and uninjured legs, and may bias group comparisons as well. Various factors have been put forward as a cause of asymmetrical postural stability, such as asymmetrical training, morphological differences, or differential neuroanatomic organization (Peters, 1988; Teixeira et al., 2011; Kapreli et al., 2006). It has been proposed that one leg is tuned for mobilizing features and the other leg for postural stability (Grouios et al., 2009), while others argue that one leg is predominantly used for the most difficult aspect of a task (Hart and Gabbard, 1997). As the etiology of leg dominancy and leg preference is not yet elucidated (Olex-Zarychta and Raczek, 2008), the common employment of leg preference as a control variable in designing experiments may lead to bias and limit experimental design options.

As athletes are a group of interest for postural stability testing, the aim of the present study was to evaluate if leg preference should be considered as a control variable in static single-leg postural stability testing in athletes. Hence, the effect of leg preference on static single-leg postural stability was considered in field hockey athletes by means of force plate and kinematics outcome measures and five leg preference tasks that differ in features of functional behavior of the lower extremities (Schneiders et al., 2010): step up, hop, ball kick, balance and pick up. As field hockey does not involve specific asymmetrical training of single-leg standing, we hypothesized that none of our leg preference tasks would have significant effects on static single-leg postural stability.

2. Methods

2.1. Participants

Sixteen field hockey athletes (8 men, 8 women; mean ± SD; age 19.1 ± 1.96 years; height 174 ± 9.3 cm; body mass 66.9 ± 9.12 kg) participated voluntarily in the present study. All participants competed in the Dutch field hockey competition at either inter-district or national level, and had at least six years of field hockey experience. A sample of field hockey athletes was recruited, since field hockey encompasses high incidence rates of ankle and knee injuries (Schmikli et al., 2009). Comparable to many other sports (e.g., tennis, volleyball, basketball), field hockey

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may involve some asymmetrical behavior which could originate from the handling of the hockey stick. However, in contrast to soccer, there is no specific asymmetrical training of single-leg standing.

All participants were healthy and did not report any (history of) neuromusculoskeletal injuries or other diseases that may affect balance performance. Furthermore, none of the participants reported any experience with balance training in particular. Written informed consent was obtained once the purpose, nature and potential risks had been explained. The study was performed according to the Declaration of Helsinki and approved by the local ethics committee. A priori estimated sample size for $\beta=0.80$ with $\alpha=0.05$ was calculated based on 'center of pressure speed' data from Hoffman et al. (1998). For a detectable difference of 10% of the mean outcome, at least 12 participants were needed.

2.2. Testing procedures

The participants performed five different motor tasks to evaluate leg preference (Hart and Gabbard, 1997; Hoffman et al., 1998; Schneiders et al., 2010; Verhagen et al., 2003): (1) *step up;* step onto a 25 cm high box, (2) *hop*; stand on one leg and hop as high as possible, (3) *ball kick*; kick a soccer ball with maximal accuracy at a 1 m wide goal, 10 m from the participant, (4) *balance*; balance on a wobble board on one leg during 10 s, and (5) *pick up*; pick up and place three marbles into a cup, one by one, using the toes while sitting on a chair. The leg that was used to step up, hop, kick a ball, balance or pick up marbles was recorded as the outcome. Each task was performed three times and tasks were performed in random order. When participants switched legs within a task, a fourth attempt was carried out. Hence, there was a possibility of a 'mixed' outcome. All tasks were performed barefoot. To ensure that preference tasks were carried out with as little contemplation on leg preference as possible, the participants were told that the tasks graded their general motor skills and thus had to be performed at maximum effort. These motor tasks were chosen as they adequately represent important features of functional behavior of the lower extremities, i.e. motor tasks with fine, unilateral non-fine, and bilateral non-fine features (Schneiders et al., 2010).

Subsequently, three valid single-leg standing trials of 20 s with the eyes open for each leg were carried out (Ross et al., 2009), during which ground reaction forces and motion capture measurements were performed. The foot orientation was aligned to a marked line on the force plate. Participants had to stand as still as possible and keep their hands on their hips. A trial was considered invalid if a participant displaced his/her standing leg, touched the floor with the contralateral leg or if a hand was used to regain balance. All trials were performed barefoot. Participants were given two practice opportunities with each leg before actual testing commenced. The initial testing leg was randomly assigned, and counterbalanced.

2.3. Data acquisition

Ground reaction force (GRF) data were collected with a 60 by 40 cm force plate (type 9218B, Kistler Instrument Corp, Winterthur, Switzerland) and sampled at 1000 Hz. Furthermore, motion capture data of the lower extremity were collected with the OPTOTRAK® optoelectronic camera system (Northern Digital Inc, Waterloo CA), which consisted of two cameras containing three sensors each. The Optotrak system measures the three-dimensional position of light-emitting diodes (LEDs) in a global reference frame with random errors <0.05 mm. The sample frequency was 200 Hz. Ten LED markers were attached to the participants' skin on positions with minimal soft tissue deformations during movement (Fig. 1). Additionally, a custom-made aluminum object with three LED markers was positioned over the sacrum. Prior to stance testing, while participants stood upright, facing the positive X-axis of the system, bony landmarks were digitized using a pointing device. The locations of these landmark relative to the technical coordinate system based on the cluster LED markers locations during task execution, were used to construct an anatomical axis system at each instant of time for each body segment (Cappozzo et al., 1995).

2.4. Data analysis

A custom MATLAB (The Mathworks, Natick, RI, USA) program was designed for data analysis. The GRF and motion capture data were filtered with a second order Butterworth low-pass filter with estimated optimal cut-off frequencies of 43 Hz and 16 Hz, respectively (Yu et al., 1999, Bisseling and Hof, 2006). Center of pressure (CoP) calculations were based on vertical and horizontal GRF in accordance with the manufacturer's manual. Joint angular velocity vectors were calculated from the instantaneous distal relative to the proximal segment anatomical axes orientation matrices according to Berme et al. (1990).

Our primary outcome measure of postural stability was the resultant 'CoP speed' (total CoP path length divided by trial time). The 'CoP speed' has been shown to be reliable (Doyle et al., 2007), and discriminative concerning single-leg stance balance (Jakobsen et al., 2011; Paillard et al., 2006; Ross et al., 2009; Wikstrom et al., 2010). Additionally, the following resultant parameters were added as secondary outcome measures: the 'horizontal GRF' (mean length of the GRF vector in the horizontal plane), the 'ankle angular velocity' (mean length of the ankle angular velocity vector), and the 'hip angular velocity' (mean length of the hip angular velocity vector). The 'horizontal GRF' is related to the amount of sway of the center of mass and to the corrective shear forces due to counter rotation acceleration of the trunk (Hof, 2007; Pintsaar et al., 1996). This parameter has been shown in few studies to be discriminative as well (Pintsaar et al., 1996; Ross et al., 2009). Angular velocities of the ankle and the hip were added since most motor corrections in single leg stance are made by ankle and hip/trunk movements (Hof, 2007; Lin et al., 2011; Tropp and Odenrick, 1988). As separate analyses of direction might provide additional information (Ross et al., 2004), all outcome measures were analyzed for each degree of freedom as well.

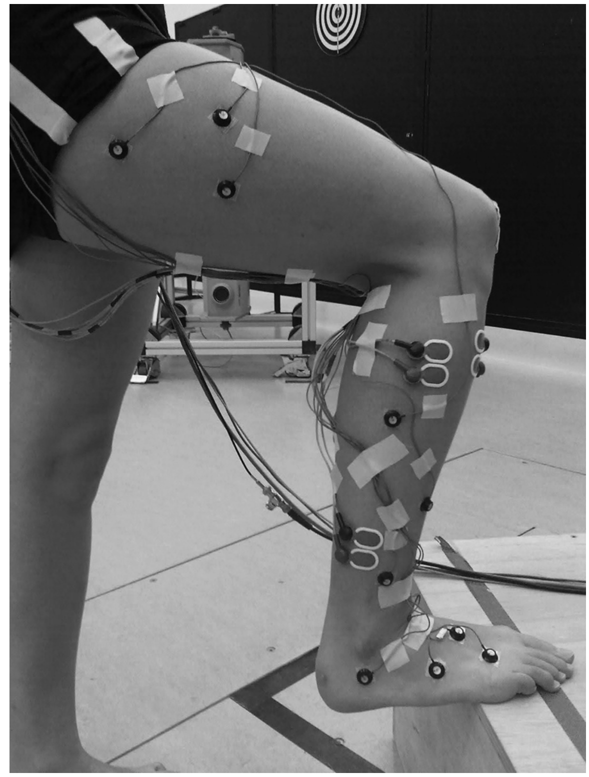

Fig. 1. Typical LED marker positioning on the lower extremity.

For each leg, the postural stability parameter outcomes were averaged over the three single-leg stance trials. Subsequently, after checking normal distribution of the data, comparisons between the preferred and non-preferred leg were performed using a paired two-way student *t*-test. The preferred and non-preferred leg may change according to the preference task evaluated. Since five leg preference tasks were performed, the postural stability outcome was analyzed according to five ways of categorizing the preferred and non-preferred leg. As the statistical analyses were performed for each categorization separately, five statistical tests were performed for the primary outcome measure. Participants with a 'mixed' outcome on a leg preference task were removed from analysis with respect to that leg preference task categorization. In view of the purpose and hypothesis of the present study, we chose not to correct the *P*-value for the multiple testing, as it would increase the chance of type 2 errors. Nevertheless, it is obvious that possible significant findings should be interpreted with the family wise error in mind.

3. Results

The results of the preference tasks are shown in Table 1 and indicate that leg preference was not consistent across tasks. The postural stability parameters are outlined in Table 2, and present the difference between the preferred and non-preferred leg, while grouping of legs was performed according to each preference task outcome. The primary outcome measure, resultant 'CoP speed', as well as the secondary outcome measures, were not significantly different ($P>0.100$) between the preferred and non-preferred legs, regardless of the employed leg preference task. Fig. 2 illustrates the effect sizes (% of mean) and 95% confidence intervals per leg preference task categorization.