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Task-specificity of balance training

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ABSTRACT

Despite much research on balance training, it is still unclear whether balance training leads to highly task-specific adaptations or rather non-specific adaptations. Hence, in this study we examined whether balance training increased performance only in the balance task that was trained or also in non-trained tasks. Forty healthy participants (28 m 12 f, 25 ± 4 years, 177 ± 10 cm, 73 ± 14 kg) were assigned to one of two training groups (TGs) or a control group. Both TGs completed six sessions over 2 weeks, only the training device differed. Before and after the training, performance in the trained task as well as in additional untrained tasks was recorded. ANOVAs showed that each TG outperformed the other groups only in the task they had trained (e.g., task trained by TG1: +225% in TG1, only +41% and +30% in TG2 and control, group * time interaction, $p < 0.001$; Untrained task 1: TG1 +48%, TG2 +48%, and control +30%, no significant interaction, $p = 0.72$). In summary, 2 weeks of balance training resulted in highly task-specific effects, no transfer even to very similar tasks was observed. Therefore, we recommend identifying and training exactly those tasks that need improvement, and test the efficacy of training programs using specific tests instead of general tests with limited functional relevance.

1. Introduction

Balance training has been recommended to improve performance in different sports (Zech et al., 2010), to prevent injuries and accelerate the rehabilitation process (McGuine, Greene, Best, & Leverson, 2000; McKeon & Hertel, 2008), as well as to prevent falls in at risk populations (Gauchard, Jeandel, Tessier, & Perrin, 1999).

However, it is still not clear whether balance training leads to highly task-specific adaptations, or more general non-specific adaptations that can be transferred to other tasks. This is a fundamental question, as the answer will greatly influence balance training recommendations as well as study design and testing procedures in future balance studies, and can help to direct the investigation of the underlying physiological mechanisms of balance training adaptations. For instance, if the effects of balance training were primarily task-specific, it would be mandatory to use task-specific tests in order to be able to detect specific neurophysiological adaptations.

In the literature, balance is often treated as a general ability. In consequence, balance is usually assessed using generic tests (e.g., one-leg stance) irrespective of training goals and type, and meta-analyses pool balance studies regardless of the type of balance training used (Lubetzky-Vilnai & Kartin, 2010; Tofthagen, Visovsky, & Berry, 2012). This approach is supported by studies that report non-specific effects of balance training such as improved gait kinematics in stroke patients

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(Yavuzer, Eser, Karakus, Karaoglan, & Stam, 2006), static stability in patients suffering from spinal cord injuries (Sayenko et al., 2010), postural corrective responses to unexpected balance perturbation in healthy subjects (Sayenko et al., 2012), or walking speed in older adults (Agmon, Perry, Phelan, Demiris, & Nguyen, 2011) and even on shuttle-run time and body sway during different postural tasks in young recreationally active adults (Yaggie & Campbell, 2006). On the other hand, several studies indicate that the principle of task-specificity also applies to balance, postural control and gait rehabilitation in old adults (Muehlbauer, Besemer, Wehrle, Gollhofer, & Granacher, 2012; Oddsson, Boissy, & Melzer, 2007), or that no effects were found when the task trained was different from the task tested in old adults (Donath, Roth, Zahner, & Faude, 2015; Kovacs, Sztruhar Jonasne, Karoczi, Korpos, & Gondos, 2013; McMurdo, Millar, & Daly, 2000) and in children (Donath et al., 2013). Furthermore, several attempts have been made to divide balance into many subcategories that seem to have little overlap. For example, the BESTest – a clinical balance test battery developed by Horak, Wrisley, and Frank (2009) – consists of 36 tests in six categories, and it has been shown that patients with deficits in one category score poorly in that category but not in the other categories, suggesting that there is no such thing as a general balance ability and that one should not expect that training one balance task improves performance in a different balance task (Horak et al., 2009)).

However, none of the studies mentioned above can – and were not intended to – directly answer the question about task-specificity of balance training adaptations, as they usually had only one training group and considerable differences between the task that was trained and the tasks that were tested. To the best of our knowledge, the present study is the first one that explicitly aimed to answer the question whether balance training leads to task-specific or rather general adaptations. We hypothesized that training one balance task would lead to performance improvements only in this task and not in other balance tasks that had not been trained.

2. Methods

2.1. Study design

During a first set of tests (PRE), balance was assessed with two different balance devices, a Posturomed (Haider Bioswing, GmbH Pullenreuth, Germany) and a custom-made tilt board (see Fig. 1), both used with two different directions of perturbation (antero-posterior AP, and medio-lateral ML) resulting in a total of four different tests. Participants were then divided into three groups using a matching procedure – picking the permutation with the least group mean differences in the performance in the four PRE tests via a Matlab script – to ensure comparable group means: one control group that did not train (C group, 12 subjects, 23 ± 3 years, 175 ± 8 cm, 71 ± 10 kg), one group which trained only on the Posturomed in ML direction (P-ML group, 14 subjects, 26 ± 5 years, 176 ± 12 cm, 70 ± 14 kg) and one group which trained only with the tilt board in ML direction (T-ML group, 14 subjects, 24 ± 3 years, 178 ± 11 cm, 75 ± 16 kg). The C group was smaller than the other two groups due to the drop-out of two subjects for reasons not related to the study (knee injury and scheduling problems, respectively). After six training sessions, all participants were tested again on both devices in both directions (POST test).

2.2. Participants

The experiments were approved by the ethics committee of the University of Konstanz and were in accordance with the latest revision of the Declaration of Helsinki. The 40 participants (12 female, 28 male, mean age 25 ± 4 years, height 177 ± 10 cm, body mass 73 ± 14 kg) were mostly students with an average physical activity level of 5 h per week (assessed via questionnaire). All participants were healthy with no history of leg injuries during the last 2 years or diseases associated with balance impairments. All participants gave written informed consent before taking part in the study and were told not to participate in any other balance training for the course of the study.

2.3. Balance devices

As shown in Fig. 1A –D, the custom-made tilt board consisted of a wooden platform (24.5 × 24.5 × 1 cm) with a gripping surface, mounted on a semicircular wooden block with a height of 6.5 cm. The aim was to bring the tilt board into a horizontal position and maintain it while standing on it with one leg. The Posturomed consisted of a movable platform that is connected to a metallic structure by dampened pendulums (see Fig. 1E and F). The platform can be kept in a stable position 2.5 cm away from its centre via an electromagnet. From this starting position, the platform can be released by switching off the electromagnet, thus inducing a damped oscillation with an initial amplitude of 5 cm. The subjects' task was to reduce the oscillations of the platform – both the oscillations caused by the release of the platform and the oscillations caused by his own movements – as fast and completely as possible while standing on one leg. The two devices were chosen because they are very common balance training and testing devices.

2.4. Balance tasks

During the PRE and POST tests, each participant had to complete four balance tasks: (i) on the tilt board with the board's rotational axis aligned with the longitudinal axis of the foot, resulting in a medio-lateral direction of