Gait & Posture 50 (2016) 137–144

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Time series of ground reaction forces following a single leg drop jump landing in elite youth soccer players consist of four distinct phases

Duncan P. Fransz[a,b,*], Arnold Huurnink[a,c], Vosse A. de Boode[d], Idsart Kingma[a], Jaap H. van Dieën[a]

[a] MOVE Research Institute Amsterdam, Department of Human Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands
[b] Department of Orthopaedic Surgery, Zuyderland Medical Center, Heerlen, The Netherlands
[c] Department of Nuclear Medicine, Academic Medical Center, Amsterdam, The Netherlands
[d] adidas miCoach Performance Centre, AFC Ajax, Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 11 December 2015
Received in revised form 12 August 2016
Accepted 1 September 2016

Keywords:
Force plate
Onsite testing
Football
Postural control
Parameter selection
Motor control

ABSTRACT

The single leg drop jump landing test may assess dynamic and static balance abilities in different phases of the landing. However objective definitions of different phases following landing and associated reliability are lacking.

Therefore, we determined the existence of possible distinct phases of single leg drop jump landing on a force plate in 82 elite youth soccer players. Three outcome measures were calculated over moving windows of five sizes: center of pressure (COP) speed, COP sway and horizontal ground reaction force (GRF).

Per outcome measure, a Factor Analysis was employed with all windows as input variables. It showed that four factors (patterns of variance) largely (>75%) explained the variance across subjects/trials along the 12 s time series. Each factor was highly associated with a distinct phase of the time series signal: dynamic (0.4–2.7 s), late dynamic (2.5–5.0 s), static 1 (5.0–8.3 s) and static 2 (8.1–11.7 s).

Intra-class correlations (ICC) between trials were lower for the dynamic phases (0.45–0.68) than for the static phases (0.60–0.86). The COP speed showed higher ICC's (0.63–0.86) than COP sway (0.45–0.61) and GRF (0.57–0.71) for all four phases.

In conclusion, following a drop jump landing unique information is available in four distinct phases. The COP speed is most reliable, with higher reliability in the static phases compared to the dynamic phases. Future studies should assess the sensitivity of information from dynamic, late dynamic and static phases.

1. Introduction

Single leg balance performance has been significantly related to functional performance [1–3] and injuries, such as ankle sprains [4] and anterior cruciate ligament (ACL) deficiency [5]. However, it has been suggested that single leg jump landing tasks may better detect differences in sensorimotor function than static single leg stance, since they are more challenging and sport specific [6–8]. A jump landing test is a dynamic task where subjects jump either from a box or to a certain height, land upon a force plate on one foot, and stabilize as quickly as possible [9].

The most commonly applied outcome measures to quantify performance of the jump landing task are the 'time to stabilization' (TTS) and the 'dynamic postural stability index' (DPSI). The TTS aims to quantify the transition from an instable situation to a stable situation. Large differences exist in TTS calculation methods, therefore studies should be interpreted and compared with caution [10,11]. Calculation of the DPSI is straightforward and quantifies the fluctuation of the resultant ground reaction forces (GRF) around the origin (mean value) for 3 s following impact [12]. Since impact forces are high, DPSI emphasizes more the landing rather than the stabilizing phase [13]. Both TTS and DPSI have shown higher outcome values for subjects with chronic ankle instability [14–16], or with ACL reconstruction [17,18], compared to healthy controls. However, their applicability with regard to injury risk and monitoring of rehabilitation still needs to be elucidated [6,13,19,20].

* Corresponding author at: MOVE Research Institute Amsterdam, Department of Human Movement Sciences, Van der Boechorststraat 9, 1081 BT Amsterdam, The Netherlands.
E-mail address: dpfransz@gmail.com (D.P. Fransz).

http://dx.doi.org/10.1016/j.gaitpost.2016.09.002
0966-6362/

Center of pressure (COP) derivatives, such as 'COP speed' and 'COP sway', have been shown to be highly reliable and valid in single leg balance performance [15,21,22]. The COP speed has been able to discriminate between subjects with functional ankle instability and healthy controls [15]. Moreover, COP speed was significantly larger for subjects with chronic ankle instability, than for copers and healthy controls [22]. Surprisingly, however, TTS and DPSI based on jump landing tests appeared to be uncorrelated with these COP derivatives of static single leg stance [8,23,24]. Moreover, no correlations were found between static and dynamic performance using the same outcome measures, i.e. 'COP speed' or 'SD of GRF' [8,25]. Therefore, one could suggest that static and dynamic tests reflect different aspects of total body sensorimotor function, implying an expanded perspective with regard to injury risk prediction, preventive actions and rehabilitation management.

Moreover, depending on the calculation method, TTS targets different time frames of the GRF following landing. This resulted in large variation in outcome values (0.5–6 s) and low correlations between calculation methods applied to the same measurement [10,11]. Therefore, distinct information may be available within the dynamic phases as well. An interesting characteristic of the jump landing task is that the landing itself, the stabilizing phase and static balance performance can be evaluated [26]. To date, a thorough and systematic evaluation of the complete COP and GRF time series following landing has not been addressed. Such an assessment will give insights in the information available in the data collected in a jump landing task, and will reveal which time frames best reflect this information. In order to facilitate the sensitivity, it is important to optimize the precision of the outcome measure (i.e. reliability or reproducibility). Both the starting point and window size applied to calculate the outcome measures may affect the reliability.

Therefore, the aim of the current study was to determine (1) the existence of possible distinct phases following a single leg drop jump landing task by means of Factor Analysis, (2) the effect of window selection on the reliability of mean COP speed, mean absolute COP sway, and mean absolute horizontal GRF, and (3) the correlation between these outcome measures.

2. Methods

2.1. Participants

The current data set was acquired at the youth academy of AFC Ajax at the start of the 2013–2014 season. We included the data of 82 players between 11 and 18 years old (mean ± SD; age 14.10 ± 1.86 years; height 1.68 ± 0.12 m; body weight 56.70 ± 13.20 kg), for whom six valid trials were available. At the time of measurements, all players were fit to perform at the highest standard of competitive soccer matches. The local ethics committee approved the research protocol and all players or parents/guardians (depending on the age of the participant) were informed in advance of the procedures involved in the testing program and provided written informed consent.

2.2. Instrumentation

Ground reaction forces (GRF) were recorded at 1000 samples/s, using a 40 × 60 cm AMTI force plate (type BP400600HF, Advanced Medical Technologies Inc., Watertown, MA, USA). The center of pressure (COP) calculations were based on vertical and horizontal forces in accordance with the manufacturer's manual.

2.3. Procedures

The players were asked to jump from an aerobic step of 20 cm height, which was placed 5 cm posterior to the force plate, located at 4 m from the wall. Players took off by means of a small jump with two feet, landed on the testing leg at the center of the force plate, and stabilized as quickly as possible. They had to balance for 15 s with their hands on their hips, whilst keeping all other movement to a minimum (Fig. 1). Before actual testing commenced, all players completed the regular warm-up, as accustomed before a training session, and performed one practice trial per leg. Both legs were tested thrice; the left leg was appointed the initial testing leg. All trials were performed without shoes. A trial was considered invalid if a player touched the floor with the contralateral leg or if arm movement was used to regain balance.

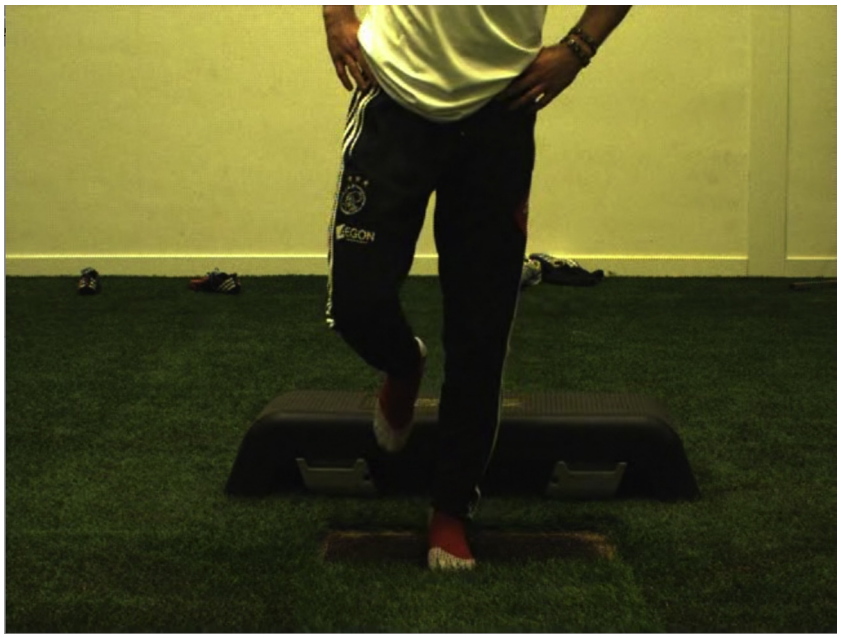

Fig. 1. The experimental setup showing one of the players during the stance phase following the single leg drop jump landing.