RELEVANCE, RELIABILITY AND LIMITATIONS OF A DROP AND STICK LANDING ANALYSIS

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The vertical force data from a drop and stick landing can be used to derive a number of variables. Previous studies have generally focused on the time to stabilization and peak force aspects, and issues related to reliability have been reported. This study investigated reliability for time to stabilisation, peak force, time to peak force, stiffness, rate of force dissipation, impulse and eccentric power (EP) among five professional elite surfing athletes. This data was also compared to data of aerial success in World Championship Tour competitions. The results revealed the best relationship between relative stiffness as well as eccentric power and completion rate of aerial manoeuvres. Further, eccentric power had the best reliability of the variables and may therefore be an interesting variable to study further.

KEY WORDS: landing, surfing, aerial, sport performance.

INTRODUCTION: Drop landings are essential in a number of sports, and have therefore been studied in different types of assessment variations (Ebben et al., 2010; Flanagan et al., 2008). At the Surfing Australia High Performance Centre, the drop and stick test (DS) is part of the general movement assessment, as it has been shown to discriminate between levels of surfers (Tran et al., 2014a) and may be important in screening athletes for excessive lower extremity injury risk (unpublished data).
It is believed that DS landing improvement through development of different physical aspects may transfer to the task of landing manoeuvres on a surfboard (Tran et al., 2014a). However, this needs to be confirmed by further research. Despite the recognition of the importance of landing tasks, it is important to find landing measures that are reliable and valid to assess landing performance for the specific group of surfing athletes, because landing skills will increase scoring potential during wave riding (Lundgren et al., 2014). Furthermore, the DS is a test that can be used both in dry land training and testing, and may serve as a quick and standardized method to assess landing ability.
Previous studies have reported landing variables such as peak force (PF), time to stabilisation (TTS), and stability index to assess the dynamic stability in a landing task (Flanagan et al., 2008; Tran et al., 2014a; Wikstrom et al., 2005). Tran et al. (In Press) reported differences between junior and senior surfing athletes regarding TTS, with senior athletes stabilizing faster than juniors (Tran et al., 2014a). Observed reliability of PF (α = 0.57) and TTS (α = 0.68-0.97) has been reported in these studies, however with highest and lowest trials excluded before data analysis (Flanagan et al., 2008; Tran et al., 2014a). In order to avoid fatigue influencing the results while testing athletes, it is important to find valid assessments that can be performed within a minimum number of trials.
This research aimed to further investigate the DS landing assessment, with the intention of observing a number of variables derived from the vertical force-time vector that may be useful for landing assessments of surfing athletes. The study also aimed to assess the relationships between landing performance and performance variables in surfing, such as success rate and scoring of aerial manoeuvres.

METHODS: Five professional male surfing athletes in the top 32 in the World (age: 29 ± 3 y, mass: 80.7 ± 3.0 kg and stature: 1.78 ± 3.4) were assessed on a DS landing task. Each

athlete completed five trials, on three separate days during the first week of the 2014 competitive year. Sixty seconds of recovery were provided between trials. Furthermore, all aerial manoeuvres from the World Championship Tour (WCT) for these athletes during the 2014 competitive year were analysed, and the success and wave scores were recorded for each of those waves.
The DS task was performed via a forward drop off a 0.5 m box and barefoot landing onto a force plate (400 Series Performance Force Plate, Fitness Technology, Adelaide, Australia) recording at 600 Hz (Tran et al., 2014a). The instruction for completion of the DS was to 'land soft' and reach a squat position with the upper thighs parallel to the floor. Each athlete was familiarized with the landing task to increase competency and the repeatability of the task.
The vertical force data was processed in Matlab R2013a (Mathworks, Massachusetts, USA) and a Butterworth filter of 27.2 Hz was applied (Yu et al., 1999). The force-time graph was processed by dividing the force by body mass, and then integrated to reveal velocity and displacement during the landing. This data was further analysed for the variables time to stabilisation (TTS) (Flanagan et al., 2008), peak force (PF), relative peak force (rPF), stiffness (k), relative stiffness (rk), rate of force dissipation between PF and TTS, impulse (Imp) from initial contact to TTS and eccentric power (EP) between PF and TTS was extracted. Cronbach's alpha was used to assess reliability of landing variables and observed for trend to correlation (due to insufficient statistical power to perform a correlation analysis) with average score of aerial waves, success rate of aerials and number of aerials during the full year of WCT competitions (n=11). Cronbach's alpha was interpreted according to the scale of $\alpha \geq 0.9$ – Excellent, $0.7 \leq \alpha > 0.9$ – Good, $0.6 \leq \alpha > 0.7$ – Acceptable, $0.5 \leq \alpha > 0.6$, and $\alpha < 0.5$ – Unacceptable (Kline, 2013). All statistical analyses were performed using SPSS 22 (IBM, Chicago, Ill.).

RESULTS: The five athletes attempted a total of 48 aerial manoeuvres, whereof 14 were successful, during the 2014 WCT competitions. These 14 successful waves had an average wave score of 5.80 out of 10 possible. There was an observed trend between success rate of aerials and rk (Figure 1) and EP, however no other clear trends were observed in these data.

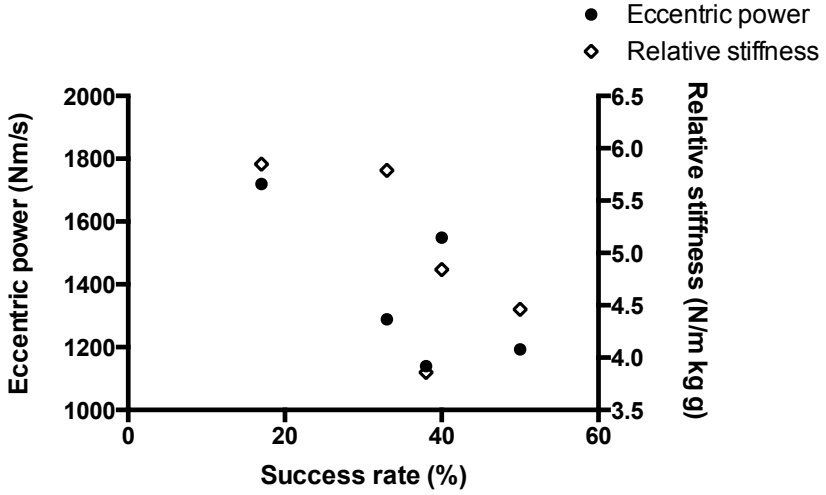

Figure 1: Trend of a relationship between relative stiffness (rk) and success rate of aerial manoeuvres in elite surfing competition.

Reliability analysis of the five trials on three different days revealed acceptable to excellent reliability within days, and poor to good reliability between days, depending on variable (Table 1). The most reliable variable was EP

Table 1
Mean (±SD) and Cronbach's alpha for all variables derived from the force data

Item	Mean (±SD)	α (within days)	α (between days)
Displacement (m)	0.51 ± 0.03	0.77	0.70
Time to stabilization (s)	0.92 ± 0.17	0.67	0.69
Peak force (N)	1910 ±165	0.71	0.84
Relative peak force (N/kg•g)	2.39 ± 0.20	0.71	0.84
Time to peak force (s)	0.09 ± 0.02	0.80	0.60
Stiffness (N/m)	3933 ± 622	0.71	0.58
Relative stiffness (N/m•g)	4.93 ± 0.77	0.71	0.56
Rate of force dissipation (F/s)	1465 ± 333	0.74	0.88
Impulse (Ns)	949.4 ± 150	0.71	0.76
Relative impulse (Ns/kg)	11.6 ± 1.53	0.63	0.66
Eccentric power (Nm/s)	1353 ± 229	0.90	0.81

DISCUSSION: Although the number of athletes in this study is a limitation, the results show a great potential for further investigation of some of these DS variables. Only professional surfing athletes were included in this study for the purpose of having the highest possible sport specific skills and competitive demands, and knowing that they all participated in the same competitions. The results show that there may be a transfer of skill from land-based landing task performance to the landing of aerials on the water with regards to the parameters relative stiffness (rk) and eccentric power (EP). However, it is suggested to include more athletes to confirm this. There may be also be other associations between variables and aerial landing performance that could not be observed in this data set, due to the limited number of athletes.

The data in this study showed that athletes who were landing more ridged and had a higher eccentric power in the DS landing, had lower success rate in their competition aerials throughout the year. Although these athletes belong to the top surfing athletes in the world, these results may raise awareness that surfing athletes would benefit from landing technique training, to increase their general landing skills, as this have been previously shown to be a highly trainable skill (Aerts et al., 2010).

An interesting finding was that among these elite surfing athletes, the TTS was not related to the success of aerials, or scores of aerial waves, although dynamic postural control would be expected to be a highly relevant skill for a surfing athlete in order to quickly regain stability in a landing task. A previous study did confirm that there are differences in DS TTS between surfing levels of junior surfing athletes, indicating that there may be a practical use for this variable when tracking development of younger athletes (Tran et al., 2014b). In this study, the TTS was used as a time limiting variable for the integration of force-time data in this study, and showed usefulness in this regards due to the potential interaction between aerial success rate, rk and EP.

A concern with the DS assessment is the moderate reliability of the TTS and PF that has been reported previously (Flanagan et al., 2008; Tran et al., 2014a), which was also confirmed in this study. However, this study showed an improvement in the PF variables reliability, which may be due to different filtering frequency of the force data, or due to a higher level of surfing athletes. Additionally, this study displayed good to excellent within-day reliability for most variables except for TTS and relative impulse. It seems therefore, that it may be difficult, even for high level athletes to precisely repeat a landing movement several consecutive times, and more so between different days. A further development of this analysis could therefore include qualitative video analysis, which has been proposed as a reliable method to assess DS landing ability (Aerts et al., 2010).

CONCLUSION: The variable eccentric power was the only variable derived from the vertical force data that had excellent within-day reliability (while maintaining good between-day reliability), and most of the DS variables included in this study showed acceptable or good reliability. Furthermore, the data in this study showed that athletes who had greater relative stiffness and increased eccentric power during the drop and stick landing assessment had lower success rate in their competition aerials throughout the year.

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