# MOVEMENT VARIABILITY: A COMPARISON BETWEEN NOVICE, EXPERIENCED AND ELITE PERFORMERS

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The purpose of this study was to investigate movement and its associated outcome variability for three levels of Olympic weightlifters performing the clean. Elite (n=2) experienced (n=5) and novice (n=5) weightlifters performed 12 lifts of the clean at 80% 1RM with 120s rest between each lift. Variability of relative phase, relative hip and knee angles and ground reaction force was calculated for each subject for the 12 trials. No significant differences were reported between groups for coordination, kinematic or outcome variability however, some differences (Fx) were reported for kinetic variability. For the majority of measures no significant differences were reported between groups for performance or outcome variability. In conclusion the traditional viewpoint of invariant movement patterns for elite performers was dismissed.

**KEY WORDS:** Variability, movement, expertise

## INTRODUCTION:

Movement variability is a topic which has received much attention in recent years and has been construed as being both beneficial and detrimental to human movement (Newell and Corcos 1993; Schmidt et al. 1979). Typically, variability research has focused on outcome invariance. Since, by definition, skilled performers exhibit less outcome variability, the assumption has been made that this is associated with low movement variability.

Button et al. 2003 investigated this concept. It was reported that skilled performers had the expected levels of decreased outcome variability in comparison to the less experienced performers. However, coordination variability between the elbow and wrist joints was greater than the less proficient performers. This was viewed as functional as it occurred without detrimental affect on outcome. In order to provide a more comprehensive view on movement variability all components of the performance need to be assessed. Previous research however, tended to concentrate on kinematics at evidenced from the aforementioned Button et al. 2003 study, the parameter of kinetic variability has not been researched with any degree of intensity particularly with respect to GRF. It has been recommended that models of movement variability account for both kinetic and kinematics of the output (Carlton and Newell 1993).

The aim of this investigation is to present a more comprehensive view on movement variability in a gross motor skill, and outline its affect on performance outcome variability. This investigation aims to enhance views on movement variability in skilled performance.

## METHOD:

The gross motor skill utilised was the clean lift. The measures of interest were kinematics (hip and knee angle) and coordination (torso-thigh) (utilising 12 subjects (elite n=2)) and kinetics (Fx, Fy, Fz) of the right leg(utilising 13 subjects (elite n=3)). Pilot testing revealed similar patterns in force production between both legs, hence it was decided to focus on a unilateral kinetic analysis. The lack of variance between legs in force production led the investigators in deciding to also focus on a unilateral kinematic analysis. The levels of performer investigated were novice (n=5) experienced (n=5) and elite (n=2/3) weightlifters. Novice subjects underwent a training protocol to teach them the clean lift to a safe standard.

**Data Collection:** Retro-reflective markers were placed on right lateral malleolus, lateral femoral epicondoyle, greater trochanter, and shoulder joint centre for the calculation of hip and knee angles. A marker was also placed on the right distal end of the barbell and this was used for the calculation of outcome. MAC (Motion Analysis Corporation, Santa Rosa, CA)

was used to measure joint and bar kinematics (200Hz), and was synchronised with an AMTI dual forceplate system for kinetic measurement (1000Hz).
Subject performed 12 reps of the clean lift at 80% 1RM with 120s rest between trials. Kinematic data was filtered using a butterworth filter at 4Hz. All data was cropped according to the start and end of the lift defined through key events in the vertical bar velocity. All cropped kinematic data was normalised to 1001 points and kinetic data was normalised to 4156 points.

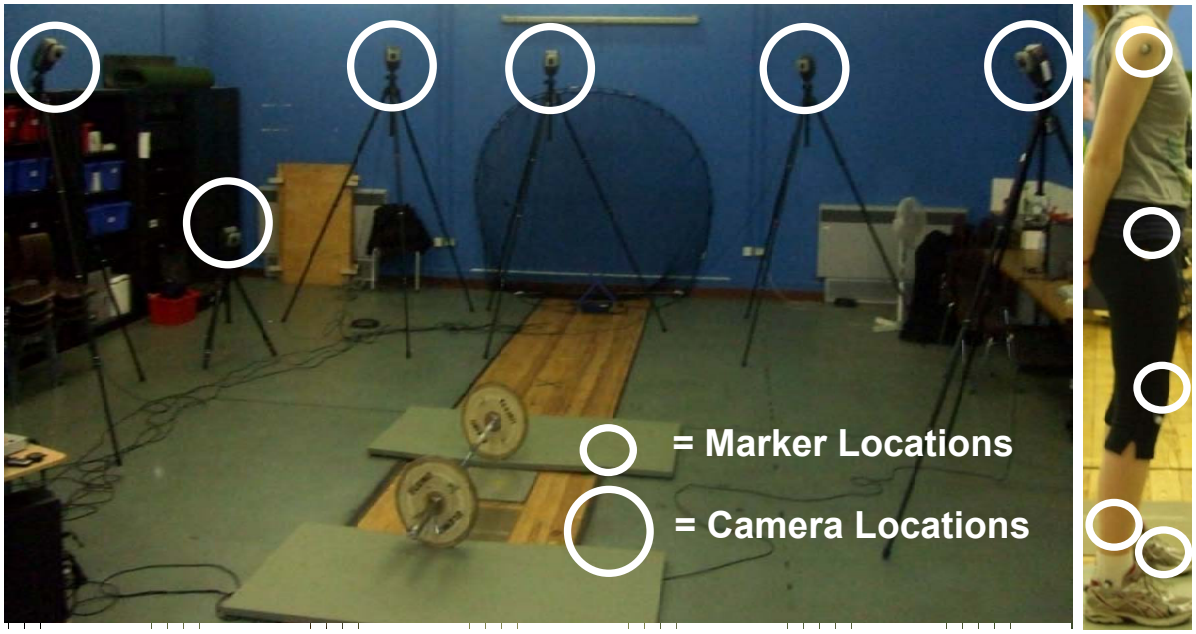


**Figure 1 - Experimental set-up and anatomical marker placement**

**Data Analysis:** Variability in performance measures was calculated through a curve averaging method. Standard deviation was calculated across 12 trials for each data point and the sum of these standard deviation values provided a variability score for each performance measure. Variability in outcome was calculated using a RMSD method measuring anterior posterior displacement of the barbell from a virtual vertical reference line originating form the starting x-position of the barbell.
A one way analysis of variance was performed to ascertain the difference between groups respect to the amount of outcome and performance variability displayed.

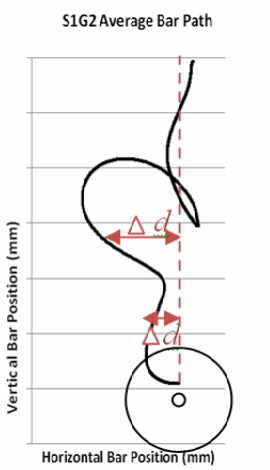


**Figure 2 - Outcome variability calculation**

**RESULTS:**
Variability scores for all performance measures are presented in figures 1 and 2. The one-way ANOVA revealed a significant difference in the right Fx measure between the elite and experienced group. No significant differences were found for any of the other performance measures.

**DISCUSSION:**
The purpose of this study was to investigate the differences between novice, experienced and elite performers in terms of movement and outcome variability. Overall no significant differences were reported between the differing levels of performer with respect to the movement and outcome variability.

The one-way ANOVA revealed no significant difference between performer levels for outcome variability.

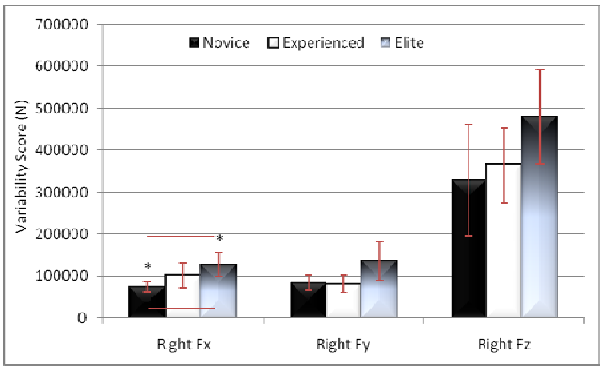


**Figure 3 - Kinetic Performance Variability, * indicates significant differences p ≤ 0.05**

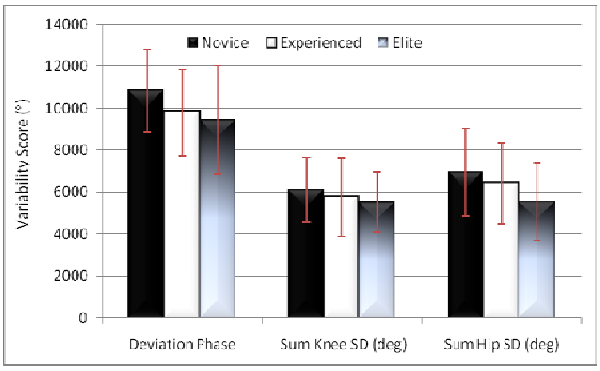


**Figure 4 - Kinematic and Coordination Performance Variability**

**Table 2 Outcome variability**

| | Novice | Experienced | Elite |
|---|---|---|---|
| Sum RMSD (m) | 0.67 ± 0.22 | 0.734 ± 0.3 | 0.53 ± 0.35 |

The lack of significant difference in kinematic and coordination measures contradicts previous functional variability research which focused on simple motor skills with accuracy as the outcome (Arutyunan et al. 1969; Scholz et al. 2000; Button et al. 2003; Robins et al. 2006). Interestingly no difference in coordination contradicts motor learning models, presenting alteration of coordination as a function of expertise (Bernstein 1967; Mitra et al. 1998; Newell & Vaillancourt 2001). It is hypothesised that changes in variability associated with learning may subside on acquisition of this complex movement pattern. The traditional view of invariant elite performance in terms of kinematics and coordination is dismissed.

With respect to the kinetic variability measures, there is little significant difference between performers for any of the three variables. However, a significant difference was reported between elite and novice performers in the Fx measure. It is interesting to relate this to the measured outcome variability as both variables occur in the sagittal plane. The highest levels of Fx variability occur with elite performers, this movement occurs in the sagittal plane, the plane in which outcome variability is measured also. This is interesting to note as the elite performers present the lowest levels of outcome variability, albeit by a small margin, in bar displacement. This could possibly represent a functional variability where the elite performers are engaging in a strategy to search the bounds of their stability in the x-plane without concomitant increases in outcome variability. This can be related to Van Emmerick and Van Wegen (2000) who reported better performers with increased variability in their centre of pressure pattern, and this was interpreted as an exploration of the bounds of their stability

Overall outcome variability was indifferent between performer groups, this was in accordance with previous literature (Arutyunan et al. 1969; Scholz et al. 2000; Button et al. 2003; Robins et al. 2006), but these levels of outcome variability were not accompanied by functional increases in performance variability as outlined by these authors.

**CONCLUSION:**

Overall, it can be concluded that an invariant performance is not indicative of an elite performer. The significant differences observed between elite and novice weightlifters in the Fx measure, may imply a functional variability utilised by elite performers in force production in the anterior-posterior plane. With respect to invariance in the outcome measure between performers, the implications are especially pertinent to weightlifting. Given that sagittal plane bar displacement is typically used as an indication of efficiency and technique, it can be concluded that this measure does not discriminate between levels of performer.

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