PRACTICE AND TALENT EFFECTS IN SWING HIGH BAR INTER-JOINT COORDINATION OF NOVICE ADULTS

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This research describes changes in movement coordination after a two-month practice period of the swing on high bar in a novice cohort, which was divided by a-priory talent level into two groups: spontaneous-talented, ST, and non-spontaneous-talented, NST. Their performance was also compared with experienced gymnasts. Data were collected during pre- and post-practice sessions by two video cameras. Coordination between hip and shoulder joints was assessed. Results showed a similar practice effect in the swing enlargements in both novice groups. Interestingly, the ST group's inter-joint coordination variables on the downswing improved more than those of the NST group due to practice. Therefore, the two novice groups improved performance, but they showed diferent local coordination. Initial talent helped to improve both performance and coordination in the down-swing.

KEY WORDS: motor perceptual-learning, novel task, initial conditions, practice effect, gymnast.

INTRODUCTION: One of the main concerns a novice must resolve when facing a new motor task is to coordinate the participation of multiple joints and limbs (Bernstein, 1967; Hong & Newell, 2006). Coordination has been defined as the stable spatial-temporal relationship among movement system components (i.e. limb segments and joints) to achieve the task's goal (Irwin & Kerwin, 2007). Limb segments and joints are in-phase coordination when they move in synchrony with 0º phase lag between them, while the coordination is in anti-phase mode when segments or joints move in opposite directions with a phase lag of 180º. However, multiple intermediate out-of-phase coordination modes exist between in- and anti-phase coordinations. Moreover, movement performance and coordination could be impacted by an individuals' a-priori talent while learning a new task (Delignieres et al., 1998; Teulier & Delignieres, 2007). The aim of this research was to describe movement coordination changes after a two-month practice period of a novel task (longswing in high bar) in a novice cohort, which was divided in two groups considering the initial level of performance: spontaneous-talented versus non-spontaneous-talented. In addition, post-practice performance and coordination of the novices were compared to expert gymnasts. Given the task characteristics, we focused on the inter-joint coordination between the hip and shoulder in this study.

METHOD: Participants: Twenty-five novice participants who never performed a lonswing in high bar prior recruitment (fifteen males and ten females, age=20.2±2.2 years; height=1.70±0.1 m; body mass=66.5±11.7 kg) were divided by a-priory talent level (spontaneous-talented, ST, and non-spontaneous-talented, NST) using a k-means Cluster analysis on the basis of their best performed swing during the first trial in the first practice session. An additional expert group was made up of nine gymnasts from the national team (six males and three females, age=19.0±4.5 years; height=1.59±0.1 m; body mass=54.9 ±15.3 kg). All participants signed a consent form. The study was approved by the local ethics committee.

Data Collection: We defined three events independently for hip (H) and shoulder (S) angle joints (Fig. 1b): the smallest angle during downswing (P1H, P1S); the largest angle after P1 (P2H, P2S); and the smaller angle during upswing (P3H, P3S). Movement performance was defined as the total path of the swing (swing amplitude) measured from the maximum elevation on the downswing (Pi) and the maximum elevation on the upswing (Pf) (Fig. 1b).

Data were collected during pre- and post-practice sessions by two video cameras. Body position angle was defined as the angle formed by the line connecting the center of mass with the middle of the grasping hand and the vertical (z-axis) of the coordinate system (Arampatzis & Bruggemann, 1999) (Fig. 1a). Swing amplitude was normalized, as shown in Fig. 1a. In order to characterize the coordination between the hip and shoulder, we defined inter-joint phases (P1H-P1S, P2H-P2S, and P3H-P3S), and used continuous relative phase (CRP) to represent the phasing relationship between the actions of the two joints at every point. Each CRP was obtained by subtracting the phase angle of the distal joint (hip) from that of the proximal (shoulder), namely $\varphi_{shoulder\text{-}hip}$ (Clark & Phillips, 1993; Hamill et al., 1999). In turn, the phase angle (φ_i) was calculated from the normalized angular displacement (θ) and angular velocity (ω) using $\varphi=\tan^{-1}(\omega / \theta)$. In Figure 1c, the continuous relative phase graph of an expert gymnast was depicted for a longswing in high bar. Relative phase began around 0º indicating that the hip and shoulder moved in synchrony or did not move remaining the same angle values. This in-phase relationship became out-of-phase lead by hip flexion starting around -80%. Around 40% of the upswing the hip achieved the maximum extension (P3H) and the coordination changed faster to an out-of phase mode leaded by the shoulder's flexion with the same velocity as the hip initiated the extension slower. To quantify and statistically test differences between relative phase curves, the mean absolute relative phase (MARP) of each hip and shoulder phases were calculated (Stergiou et al., 2001).

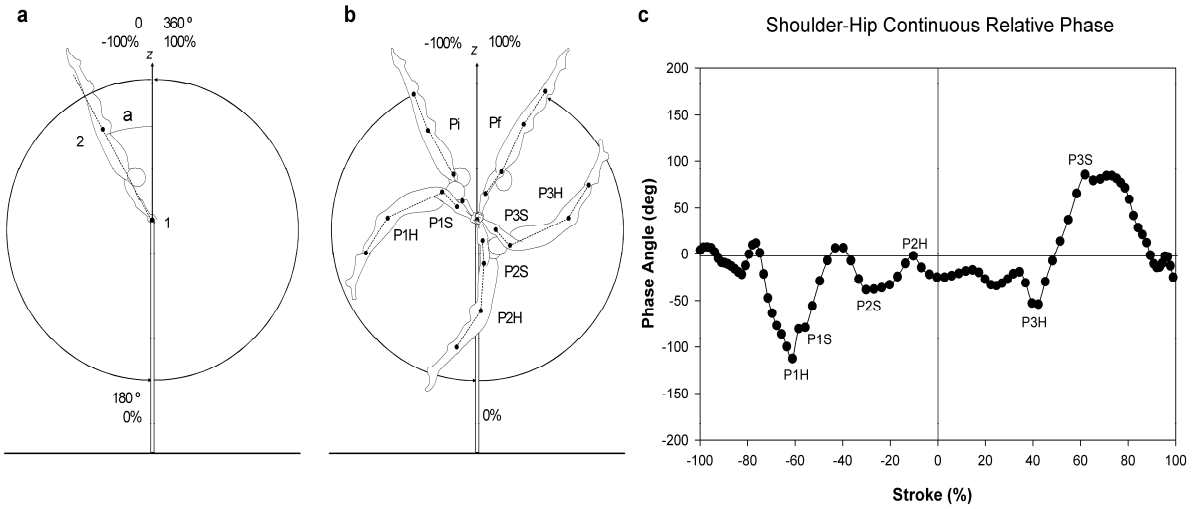

Figure 1: In (a), swing normalization and body position angle (a) defined by the z axis, middle grasping hand (1) and the body center of mass (2). In (b), initial position (Pi), final position (Pf) and swing events (P1, P2, and P3) from hip (H) and shoulder (S) movements. For simplicity, H and S events have been represented at the same instant of time for P1-P3. In (c), the continuous relative phase between the hip and shoulder joints during a longswing in an expert gymnast.

Data Analysis: To address the changes in performance and coordination between pre- and post-practice of the NST and ST groups, we used 2 (Group) X 2 (Time) mixed ANCOVAs with group as the between-participants factor, time (first and last trial) as the within- factor, and sex as the covariate. Planned comparisons between pre- and post-practice within each group were used. In addition, NST vs. ST group effects on the magnitude of change (post-minus pre-practice) were examined using students' t-tests for all variables. To address the secondary goal of this study, one-way ANCOVAs with Tukey multiple comparison post hocs were used for establishing differences between the NST, ST and Expert groups at the last trial. Sex (male and female) was included as the covariate in all statistical tests. Statistical significance was set at $p<.05$ level. P adjustments were conducted to control for multiple comparisons when appropriate.

RESULTS: We conducted 2x2 ANCOVAs for the swing amplitude, each inter-joint phase and MARP to investigate which parameters evolved differently between the groups. These analyses revealed that there were significant group ($F_{1,22}$=8.44, p=.008) and trial (time) ($F_{1,22}$=11.51, p=.003) main effects for the swing amplitude. In addition significant group by time interactions were found for P1H-P1S ($F_{1,22}$=10.01, p=.005) and P2H-P2S ($F_{1,22}$=5.28, p=.032). Indeed, simple main effects showed that the ST group improved P1H-P1S and P2H-P2S from pre- to post-practice (becoming closer to reference values, in this case values of the Expert group) while the NST group worsened despite practice (Table 1). When student t-tests compared the pre- and post-practice magnitude of change, significant differences existed between the NST and ST groups on P1H-P1S ($F_{1,22}$=10.01, p=.005) and P2H-P2S ($F_{1,22}$=5.28, p=.032). The sex covariate showed significant differences for the MARP P3H-Pf ($F_{1,22}$=5.34, p=.031) and MARP P3S-Pf ($F_{1,22}$=8.29, p=.009). Examining group differences at post-practice, the One-way ANCOVAs pointed out differences between expert and novice for the swing amplitude ($F_{2,30}$=118.70, p=.000) and the P2H-P2S inter-joint phase ($F_{2,30}$=4.63, p=.018). The post hoc test showed significant differences between both novice groups (ST and NST) and the experts for the swing amplitude, but there were not significant differences in paired group comparisons in P2H-P2S. The sex covariate was significant in One-Way ANCOVA time for P3H-P3S ($F_{2,30}$=4.73, p=.038).

Table 1 Participant characteristics and pre- and post-practice swing details,

	Pre		Post		
	NST (*n* = 15)	ST (*n* =10)	NST (*n* = 15)	ST (*n* = 10)	E (*n* = 9)
	Mean±sd	*Mean±sd*	*Mean±sd*	*Mean±sd*	*Mean±sd*
Swing Amplitude (%)	80.03±15.49	104.02±18.06	98.72±14.17	115.92±23.64	198.40±0.96
Inter-joint Phases [a]					
P1H-P1S	-4.37±12.12	-10.37±19.19	-15.80±18.61	-1.95±3.71	-6.45±20.15
P2H-P2S	-7.53±11.90	-7.24±15.91	-13.92±14.18	-2.44±10.05	1.09±12.77
P3H-P3S	-10.33±8.69	-10.33±17.80	-14.20±10.80	-13.14±12.67	-21.24±5.35
Swing MARP					
MARP P1H-P2H	42.41±25.06	37.28±18.47	47.84±22.96	49.76±16.35	41.86±23.85
MARP P2H-P3H	43.82±20.71	37.89±14.47	38.16±13.33	41.14±22.39	39.28±14.20
MARP P3H-Pf	42.04±23.16	45.98±17.14	49.63±20.30	49.92±22.75	46.84±25.41
MARP P1S-P2S	36.82±18.05	53.12±36.31	35.89±20.56	43.54±20.80	34.40±21.27
MARP P2S-P3S	39.16±22.93	43.14±21.96	42.20±17.66	33.94±12.26	37.58±14.69
MARP P3S-Pf	62.98±27.69	51.24±23.51	80.92±59.40	64.31±28.99	53.67±31.24

[a] All values in swing amplitude percentage

Overall, these results suggest novice participants improved their performance due to practice independent of group membership. However, novice group differences remained relevant across time. Group differences for the inter-joint phases mainly occurred in the downswing (-100-0%) while sex differences were revealed in the upswing (0-100%). When examining P1H-P1S and P2H-P2S, the ST group became closer to the experts by shortening these phases closer to an in-phase relationship between the hip and shoulder. In contrast, the NST group increased the phase durations closer to an out-of-phase coordination.

DISCUSSION: The main aim of this study was to describe coordination changes in the acquisition of a novel task (swing on high bar) due to practice and initial talent. It was hypothesized that within the novice cohort, participants with spontaneous talent would experience larger improvements than those less talented. However, our performance variable did not support our hypothesis while inter-joint phases variables yielded significant interaction effects.The P1H-P1S and P2H-P2S critically differentiated the two groups. The ST group reduced the time lag between the events of hip and shoulder during the downswing (-100-0%) becoming an in-phase coordination with closer values to experts. The NST group

after practice worsened the two inter-joint phases with an out-of-phase coordination. These modifications could impact differently the goal achieved (swing amplitude) by the novice groups. Thereby, the ST group coupled the two movements in order to exploit the mechanical work of the gravity while the NST group separated the hip and shoulder events to increase the segmental velocities.

After the practice the novices achieved similar MARP values which did not differ from experts values. However, similar MARP values do not imply necessarily an improvement because different coordination modes could result in the same average. When we observed the continuous relative phase (CRP) graphics, the relationship between both joints the hip and the shoulder changed across 0º faster achieving larger values in novice groups, while the experts modified their coordination over a more expanded period of time.

CONCLUSION: In summary, our findings have shown that the novice participants improved the swing amplitude, but the coordination in the downswing was different for the ST and the NST groups. The ST group inter-joint phases during the down swing appeared more similar to the expert group. In contrast, the MARP values did not show differences between novices groups or expert group, perhaps due to the use of an average of different coordination modes. We suggest that the initial talent also helps to improve coordination in the downswing. Despite of talent level, upswing coordination will required more focused practice. Given the sex covariate was significant further exploration of these results are warranted.

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Acknowledgement

Support for this work was made possible by Secretaria General de l'Esport and the Departament d'Universitats, Recerca i Societat de la Informació (DURSI) of the Generalitat de Catalunya.