P02-14 ID17

ANALYSIS OF THE SPRINT START, SWIMMING START AND VOLLEYBALL PUSH OFF IN GENERATING IMPULSE-MOMENTUM

Hashem Kilani[1], Mohammad Abu Al-Tuieb[2], Maher Kilani[2]

[1]Sultan Qaboos University, College OF Education, PHED, Muscat, Oman
[2]Hashemite University, College of Sport Sciences, Zarqa, Jordan

The purpose of this study was to investigate the relationship between impulse and change of momentum in three types of ground take-off. Three athletes from the swimming, sprinting and volleyball national teams executed three trials from an AMTI force platform synchronized with video capturing system of starting take-off. APAS software was used for further analysis. Results indicate that the swimmers and the sprinter are less capable of getting equal impulse relationship to the change of momentum due to deviation of reaction forces into the desired motion.

KEY WORDS: impulse- momentum, sprinting and swimming take-off.

INTRODUCTION: In most sport situations, a push-off by feet is required to produce forces into the desired direction of a motion. The push-off is a function of force action through time history which should be optimized to produce a quality of momentum. The acceleration of a body parallel and directly proportional to the net force (F) acting on the body is in the direction of the net force, and is inversely proportional to the mass (m) of the body i.e., $F = ma$ (Second Newton's law). This impulse produced should be equal to the momentum outcome to the movement directions at the start of sprinting and swimming. At the same token, the vertical jumping take-off in volleyball also requires a force against the ground so that reaction forces are produced into the opposite desired direction (Third Newton's Law). Therefore, any deviation of reaction forces into the desired motion or any absorption of the force produced by the body system assumed to affect the momentum into the desired reaction. A distribution of the 3 reaction forces may alter the optimum movement in comparing the execution of push-off between sprint start, swimming start and vertical jump in volleyball.

In sprinting, the percentage contribution of the starting block as a fast reaction time to the acceleration phase was recorded up to 76%. (Milan et al, 2006)

In swimming, the good start contributes 25% of the total time for the 25-yard race, 10% of the total time for the 50-yard race, and 5% of the total time for the 100-yard race. Although improving the start reduces the time of the race at least 10% of a second. (Kilani & Zeidan, 2004; Adrian & Cooper, 1995)

The mastery of some skills in volleyball such as serving punch, blocking defense, and the smashing offense require a high-performance vertical jump. This needs a great potential of the lower extremity leg power making a good balance and produce appropriate impulse to generate an appropriate momentum. This, in turn allows athletes in the three skills mentioned above to perform the highest vertical velocity during their take-off, resulting in a bounce higher and longer flight time. (Jadidi & Kilani, 2010) The direction of the force must coincide with the direction of body push-off at sprinting, swimming and vertical jump in volleyball. This principle can be achieved with minimum torque and moments at ankle joints. (Hay, 1993) The purpose of this study was to compare some of the biomechanical variables due to impulse momentum relationship at push-off between sprinting start, swimming start and vertical jumping strike in volleyball.

METHOD: The best three players were selected intentionally from the national teams of sprinting, swimming and beach volleyball in Jordan to serve in this study. See table 1. They were filmed using a digital video camera (Sony, 25-Hz) from the sagittal plane of their execution from an AMTI force platform synchronized with APAS system for analyses. The force platform was mounted on the block start for the swimming matching the angle of the start. Forces and impulse were normalized to the subject's body weight for comparisons.

Anterior posterior and vertical impulses were analyzed as they considered more important than the lateral for the desired trajectory path. Angles of take off are determined for each condition from V & H velocities of the CG. The best trial according to best time recorded for take-off was digitized and an18-point body model was used for determining the CG of the sprinters for analysis. Figure 1

Table 1
Demographic data of the participants in the study

	Age (yr)		Height (m)		Weight (kg)	
	Mean	SD	Mean	SD	Mean	SD
Sprinters	22	5.6	1.73	0.062	68.6	10.05
Swimmers	19.7	2.5	1.77	0.083	71	7.2
Volley ball players	26	5.1	1.86	0.042	77.7	15.3
Total	22.5	7.1	1.78	0.16	72.4	17.6

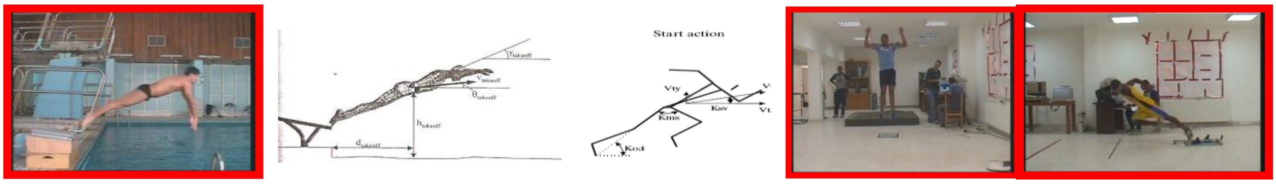

Figure 1: Take-off on force platform. It illustrates capturing protocol and angle of CG relative to horizontal.

Players performed three trials of each crouch sprinting take-off, swimming start push-off and vertical jump, as doing the block skills in volleyball. The following order was set for determining image coordinates (right toe, heel, knee, and hip; left hip, knee, heel, and forefoot; top right hand, wrist joint, elbow joint, and the right shoulder joint; left shoulder joint, elbow, wrist joint, top left hand; and the highest point in the head). Cameras were field-synchronized by light bulb diot using the frame matched. Digitized data were smoothed with a Butterworth digital filter at 2-4Hz. The CG location of the subject was determined by segmental analysis and described graphically. CG angles, velocities and accelerations were also calculated at each take off and push off using APAS software. The integral following formula was used to calculate the area under the curve of the vertical & anterior-posterior impulses: $\int_{t_0}^{t_n} F dt = \left(\frac{t_n - t_0}{3n}\right)\left(F(t_0) + 4F(t_1) + 2F(t_2) + ... + 2F(t_{n-2}) + 4F(t_{n-1}) + F(t_n)\right)$
Means, standard deviation, sequence, percentage, Kendall's tau-b (non-parametric) correlation coefficient and Mann-Whitney test (non-parametric) were calculated for comparative purposes.

RESULTS: Table 2 represents the means and the standard deviation for selected parameters of the three sports take-off. It is clear that force time histories in swimming and sprinting (0.57, 0.44, and 0.3 s) are greater than in the volleyball take-off respectively. The impulse is also greater (220, 248.2, and 287.7 Ns) in the volleyball vertical take-off than the other take-off in swimming and sprinting. However, horizontal forces are greater (348.9, 387, and 53.86 Ns) in the swimming and sprinting than in volleyball take-off due to the fact that different trajectory angles are responsible to their take-off paths. See figures 3-5.

Table 2:Selected biomechanical parameters in the three sporting take off.

	Swimming		Sprinting		Volley ball	
	Mean	SD	Mean	SD	Mean	SD
Force time history (s)	0.57	0.06	0.44	0.02	0.3	0.017
Mean H. F (Ns)	348.9	11.15	387	47.8	53.86	18.32
Mean V. F (Ns)	157.9	25.73	408.3	58.34	699.3	52.44
Resultant F (Ns)	383.7	0.97	562.9	71.34	87.5	16.51
Angle of push (degree)	24.3	4.16	46.4	2.56	85.6	1.24
Impulse (Ns)	220	22.91	248.2	14.64	287.7	9.8
Momentum(kg/m/s)	203.28	25.1	225.5	47.99	249.27	51.44
Resultant V.(m/s)	2.87	0.08	3.27	0.20	3.21	0.03

In Table 3, a non-parametric statistics using Mann-Whitney rank of significant is presented. There were no significant differences between impulse and momentum for the three conditions: sprinting, swimming, and jumping take-off in volleyball.

Table 3: Mann-Whitney ranks of the selected parameters in the three sporting take-off

Sport	Parameters	Mean	Total rank	Z score	P value
Swimming	Impulse	4.33	13	-1.091	0.275
	Momentum	2.67	8		
Sprinting	Impulse	5	15	-0.655	0.513
	Momentum	2	6		
Volley ball	Impulse	4	12	0.655-	0.513
	Momentum	3	9		
Swimming	Angle of push in	5	15	-1.96	0.05
	Angle of push-off	2	6		
Sprinting	Angle of push-in	5	15	-1.96	0.05
	Angle of push-off	2	6		
Volley ball	Angle of push-in	4	12	-0.655	0.513

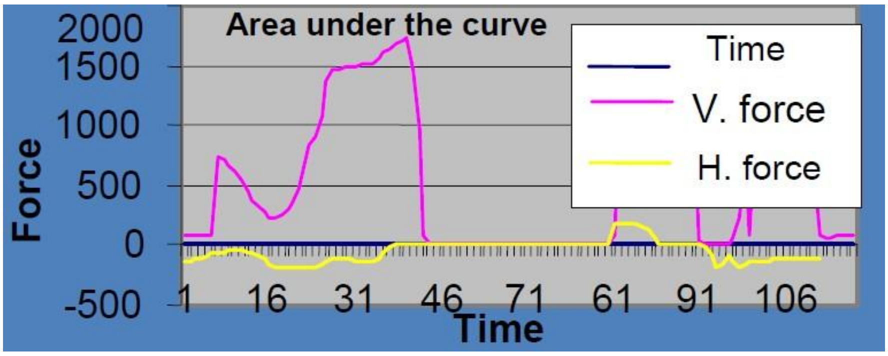

Figure 3: Sample of the ground reaction forces in volleyball vertical jump

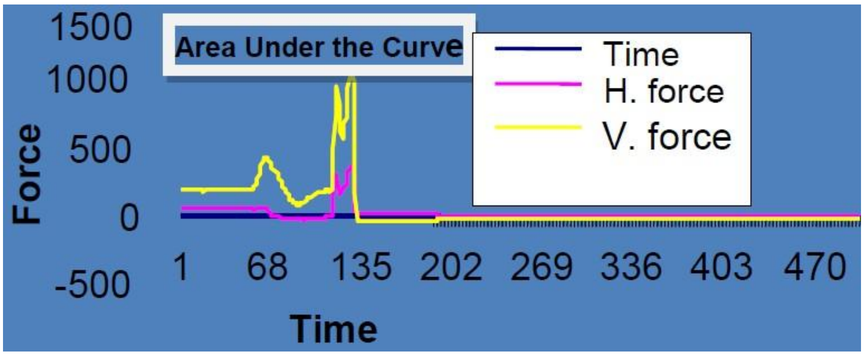

Figure 4: Sample of the ground reaction forces in sprinting take-off

However, there were significant differences in swimming and sprinting and none was found in volleyball take-off and push angles. In addition, no statistically-significant relationship was found between impulse and momentum, and there were some statistically-significant differences between the directions of the resultant force impulse and the direction of the trajectory CG velocity momentum at the instant of take off from the block in swimming and sprinting.

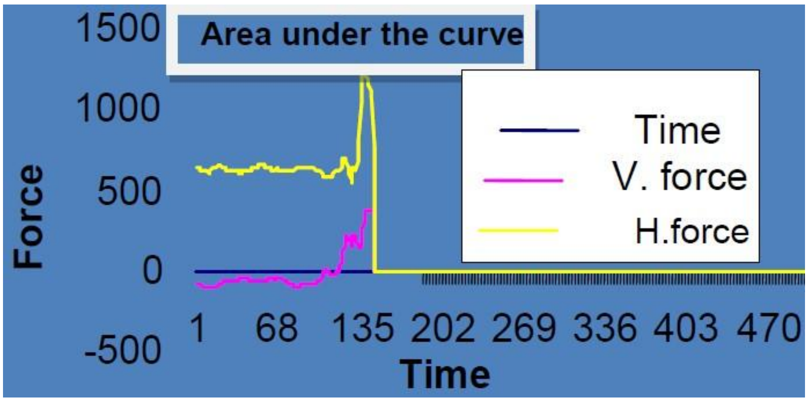

Figure 5: Sample of the ground reaction forces in swimming take-off

DISCUSSION: Table 2 and Figure 1 show that the swimming start may get swimmers off the starting block a little slower than the sprinters and in volleyball take-off but get the player out further (0.57, 0.44, and 0.3 s.). The take-off in sprinting, compared to the swimming take-off, allows the sprinter to exert a higher force against the blocks for the longest practicable time which in turn produces the maximum impulse so that the athlete leaves the blocks with the greatest possible velocity. The sprinter must be capable of developing a high force rate combined with a high maximum force, especially in the horizontal (anterior-posterior) direction. Once the sprinter has projected his CG from the blocks at a low angle (46.4 degrees) relative to the ground, the following 2-post block steps should occur with the total body centre of gravity ahead of the contacting foot at foot strike to minimise potential horizontal braking forces. This is not the case in swimming projection because the swimmer needs a lower the angle of projection to dive into the water (24.3 degrees).Nevertheless, the volleyball vertical jump producing greater impulse than the other take-offs. This is might be due to the counter movement jump which influences the impulse as it is shown in Figure 2. Eccentric contraction preceded the concentric contraction which increases the potential energy shown in the impulse take off. There are also a few observations that can be made that relate to the qualitative nature of the impulse-momentum theorem from Table 3. The only significance occurred was between angles of push-in and push-off in swimming and sprinting take off. This indicates that sprinters are not perfect in optimising their technique to the best utilization of input (impulse) to the direction desired of the CG of their body. If a force is acting for a given amount of time, it will change an object's momentum. Therefore, a force will change the velocity of an object. If the velocity of the object is changed, then the momentum of the object is changed. (Schilling et al 2008)

CONCLUSION: Since one tenth of a second is very important to the sprinters' and swimmers' performances, more feedback of their impulse curve need to be mastered in order to develop the right orientation to the geometry of the body at the push-off, and to discover weakness and improve the performance in safety technique.

REFERENCES:

Adrain, M., and Cooper, J. (1995). *Biomechanics of Human Movement*. (2nd ed). WCB Brown & Benchmark.

Jadidi, K & Kilani, H. (2010). Kinematical Parameters Contribution to the Flight Height Using One-Foot or Two-Foot Take-Off. In: *Proceedings of the XXVIII ISBS.* Marquette, Michigan, USA, 19- 23 July

Kilani, H. & Zeidan, W. (2004). A kinematic comparison between the semi- finals and the finals for 50m swimming races of the four strokes. *In: Proceedings of the XXII ISBS*, Ottawa, Canada.

Schilling B., Falvo M., & Chiu L. (2008). Force-velocity, impulse-momentum relationships: Implications for efficacy of purposefully slow resistance training. *Journal of Sports Science and Medicine* 7, 299-304.

Hay, J. (1993). *The Biomechanics of Sport Techniques*, (4th edition), Englewood Cliffs (NJ) Prentice-Hall.

Milan, C., Katja, T., and Stanko, S. (2006). The Biomechanical Model of the Sprint Start and Block Acceleration. *Physical Education and Sport*, 2 (4), 103-114.