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Visualisation of selected technical aspects in elite triple jumpers

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Introduction

The triple jump (TJ) includes the specificity of complex coordinative and technical abilities, particularly the jumping rhythm and time management, a good take-off coordination into the hop (H), step (S) and jump (J) as well as the balance (equilibration) during jumping flight. Quoted triple jump specific and performance limited characteristics are low horizontal velocity deficits during take-off phases, improvement of the jump-distance relation of H and S concerning duration, jump-height and horizontal velocity (Fukashiro et al. 1981, Fukashiro & Miyashita 1983, Yu & Hay 1996) and percentage optimisation of the phase distances (H: 35-36%, S: 30-31%, J: 33-35%). In addition knee and hip angles during take-off phases seem to be quality criterias of triple jump performance (Yu & Hay 1995, Perttunen et al. 2000). Aim of our training and competition accompanying project is to observe the above mentioned movement characteristics in the actual leading national resp. international male and female triple jumpers. Beyond this kinematic data collection we compile a routine visualisation system of selected technical aspects.

Methods

Within a scientific project (supported by a grant of the Federal Institute of Sports Science (VPN 0407/16/15/2002)) and in cooperation with the German Athletic Association (DLV), we analysed up to 522 competition-jumps (e.g. German (DM) and European Championships (EM) 2002) of 46 male and 35 female international triple jumpers during the outdoor-season. The jumps were registered by a professional digital video camera (CANON XM-1 (Canon, Japan) and a laser velocity (Laveg) measurement system (LDM 300C (Jenoptik, Jena)). The camera has been placed perpendicular to the H-S transition in order to capture the side movement of the plane of motion. Markers were placed each meter between 5 m prior to board and landing pit to calculate selected phase distances (PD). The field of view covered a distance of ~6 m of the runway. 2D-kinematic analysis was performed with DartTrainer 2.0.15.0. (Dartfish, Fribourg) and AdGraph (Basis, Munich) software. The Laveg was placed in running resp. jumping direction to measure the distance between the laser detector and the reflecting object (100 Hz). The laser beams were directed on the lower back of the athlete to determine instant speed values throughout the athlete began to run until the land in the sand. The raw data and the calculated speed curves (9pt and 67pt moving average) were registered real-time and stored in a PC (Sport 3.9 (Jenoptik, Jena) software).

Results

To visualise the complex TJ-movement we used so-called StroMotion™ panorama images resp. videos (Fig. 1). This technology includes an image line in one picture, i.e. breaks down a moving object into a frame-by-frame sequence to highlight position and trajectory. In addition selected videos were combined with synchronised velocity curves, realised with AdGraph (Fig. 2). Both visualisation techniques gave excellent multiplex information to coaches and athletes. Selected results of our velocity and distance measurements were: average competition performance of finalist DM vs. EM: Δ -8.5% (women (w)), Δ -7.7% (men (m)); average maximum reached velocity (v_{max}) in run-up (DM vs. EM): Δ -3.5% (w) resp. Δ -2.9% (m); PD-relation of DM finalists: 36.6% H, 28.4% S, 35.0% J (w) and 36.9% H, 29.9% S, 33.3% J (m), of EM finalists: 37.3% H, 27.5% S, 35.2% J (w) and 37.4% H, 29.5% S, 33.0% J (m); world-class performances reached peak values in v_{max}: 10.6 m s^{-1} and PD of H and J: each >6.0 m; significant coherences of v_{max} resp. $v_{transition\ hop}$ and effective (official plus toe-to-board) distance in males and females (p≤0.05).

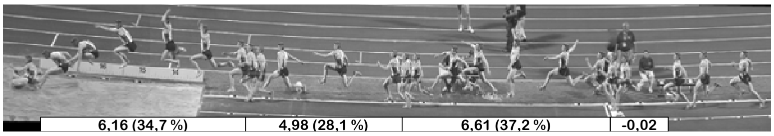

Fig. 1: StroMotion™-image (European Championships 2002)


Fig. 2: AdGraph-sequence

Discussion/Conclusion

In summary we found hop-dominated jumps in national male and female TJ in contrast to more jump-dominated or balanced techniques in world-class performances (>17.40 m in males; >14,50 m in females). A high run-up velocity, paired with short contact times and with a more balanced jump technique or a lower peak run-up-velocity, combined with a lower jump-height (H) and a balanced jump technique leads to big overall distances. An elevated reduction of horizontal velocity can be influenced due to a large hop, translatoric resp. rotatoric instabilities of the upper body and above-average deflections of knee resp. hip during the hop-step- and step-jump-transition.

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Time management and velocity profiles in elite triple jumping

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Introduction

The achieved distances in triple jump (TJ) strongly dependent upon the available horizontal velocity in run-up and each of the take-offs (TO). Kinetic energy is produced through the approach speed in every TO and is converted into height and distance. Due to less information in literature, the aim of our competition accompanying project is to detect velocity profiles and individual time managements (TM) in different performance levels, techniques and between gender.

Methods

Within a scientific project and in cooperation with the German Athletic Association (DLV), we analysed up to 348 competition-velocity profiles (CVP) (e.g. international Meetings (2002, 2003) German (GCh) (2002, 2003) and European Championships (ECh) 2002) of 37 male and 30 female elite triple jumpers during the outdoor-season. The run-up and jumps were registered by a laser velocity (Laveg) measurement system (LDM 300C (Jenoptik, Jena)), placed in approach direction to measure the distance between the laser detector and the reflecting object (100 Hz). To determine instant speed values throughout run-up until land in the pit, the laser beams were directed on the lower back of the athlete. The raw data and the calculated speed curves (67pt moving average of distance and speed) were registered real-time and stored in a PC (software: Sport 3.9 (Jenoptik, Jena), LavegDrei (Huber, Munich) and AdGraph (Basis, Munich)). Additionally a professional digital video camera (CANON XM-1 (Canon, Japan)) was placed perpendicular to the H-S transition in order to capture the side movement of the plane of motion. 2D-kinematic analysis (e.g. stride pattern (SP), calculation of selected phase distances (PD)) was performed with DartTrainerPro 2.5.3 (Dartfish, Fribourg) (Niessen et al. 2003).

Results

World class performances in TJ reached peak velocity values in run-up (v_{max}) of > 10.2 m s^{-1} in men (TJ > 17 m) and > 9.1 m s^{-1} in women (TJ > 14.5 m). Further results of male and female TJ pointed out significant correlations between run-up velocity indices (VI) ($p \leq 0.001$) and effective distance (official plus toe-to-board) as well as second last stride ($p \leq 0.05$). High significant differences were observed for CVP indices in run-up and TOP_H as well as for TM indices in run-up (15-2m (men (m) and 15-0m (women (w)) prior to board and hop-step transition between high (m: >16.5m; w: >14m) and low (m: <16.5m; w: <14m) level TJ (Tab. 1).

CVP	v (m s^{-1})	**run-up**					**board**	**TOP_H**	**Trans**	**TOP_S**	**Trans**	**TOP_J**
Level	**eff. D.**	**15 m**	**10 m**	**5 m**	**2 m**	**1 m**	**0 m**	**+0.5 m**	**H-S**	**+0.5 m**	**S-J**	**+0.5 m**
>16.5m	16.9±0.4m	9.8±0.5	10.1±0.4	10.3±0.4	9.9±0.4	9.8±0.4	9.8±0.4	9.8±0.4	8.9±0.2	8.6±0.2	7.5±0.4	7.3±0.4
<16.5m	15.8±0.3m	***2.1%⇩	***2.3%⇩	***2.7%⇩	***2.1%⇩	***2.7%⇩	***2.9%⇩	***2.5%⇩	*1.4%⇩	*1.6%⇩	0.0%⇨	0.5%⇩
>14m	14.4±0.3m	8.6±0.3	8.9±0.3	9.1±0.2	8.9±0.2	8.7±0.3	8.7±0.3	8.6±0.3	7.9±0.3	7.9±0.3	6.7±0.2	6.6±0.3
<14m	13.0±0.5m	***4.9%⇩	***4.9%⇩	***4.9%⇩	***4.0%⇩	***3.8%⇩	***3.5%⇩	***3.8%⇩	12%⇩	8.9%⇩	6.8%⇩	6.3%⇩
TM	**t (s)**		**run-up**				**board**	**TOP_H**	**Trans**	**TOP_S**	**Trans**	**TOP_J**
Level	**off. D**	**n=x**	**15-10 m**	**10-5 m**	**5-2 m**	**2-1 m**	**1-0 m**	**0-0.5 m**	**0.5-H-S**	**H-S-0.5**	**0.5-S-J**	**S-J-0.5**
>16.5m	16.9±0.4m	57	0.5±0.0	0.5±0.0	0.3±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.6±0.0	0.1±0.0	0.5±0.0	0.1±0.0
<16.5m	15.7±0.5m	191	***2.4%⇧	***2.5%⇧	***3.2%⇧	*1.6%⇧	0.4%⇧	1.5%⇧	***5.5%⇩	*2.8%⇧	*4.3%⇩	3.5%⇧
>14m	14.3±0.3m	30	0.6±0.0	0.6±0.0	0.3±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.6±0.0	0.1±0.0	0.5±0.0	0.1±0.0
<14m	12.9±0.5m	157	***5.0%⇧	***5.1%⇧	***5.0%⇧	***3.4%⇧	***5.2%⇧	*3.3%⇧	***8.5%⇩	**4.7%⇧	3.6%⇩	2.2%⇧
ANOVA	p≤0.001***	p≤0.01**	p≤0.05*									

Tab. 1: Velocity and time management profiles of top level female and male TJ during run-up, transition (trans) phases and take-off positions (TOP) of hop (H), step (S) and jump (J)

Discussion/Conclusion

In summary time management profiles were similarly in male and female elite TJ, but point out significant differences in run-up and hop to step between high and low level TJ. CVP behaviour was analogue in both gender, but with inter-individual (Δ up to 12%) and intra-individual (Range: 0-12%) different amounts of VI. High level TJ achieved higher velocities prior to board due to the stride pattern "long-short" (2^{nd} and last stride) as well as short contact times during H-S transition. Horizontal velocity drops during TOP hop, step and jump (Hay 1992) were higher in male (-1 m s^{-1}) than female (-0.7 m s^{-1}) TJ due to larger phase distances (Niessen et al. 2003). In conclusion high v_{max}, scarcely loss of horizontal velocity in TOP_H and Trans H-S are important factors for top level TJ distances in particular.

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Technique alternatives in elite triple jumping: behaviour and influence of speed

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Introduction

Cross-section analyses point out three technique alternatives in elite triple jumping (TJ), primarily in men, but no well-defined technique model. Through visualisation and kinematic analyses of selected technical aspects (e.g. Niessen et al. 2003 & 2004) we can state a classification of so-called “Speed-Jumper” (SpJ), “Power-Jumper” (PoJ) and “Twin-Arm-Jumper” (TwJ). Due to scarcely information in literature, the aim of our competition accompanying project is to analyse the behaviour and influence of speed on above mentioned technique alternatives in elite TJ.

Methods

Within a perennial scientific project in cooperation with the German Athletic Association (DLV), we compiled up to 1987 competition-velocity profiles (CVP) (e.g. international Meetings (2002-2004), German (2002-2004) and European Championships (2002)) of among several male elite triple jumpers during outdoor-seasons (Niessen et al. 2004). Velocity was registered by a laser distance device (LDM 300C (Jenoptik, Jena); 100 Hz) through run-up and jumps, placed in approach direction and directed on the lower back of the athlete. Collected speed curves were edit and filtered by 67pt moving average of distance and speed (Sport 3.9 (Jenoptik, Jena), LavegDrei (Huber, Munich)). Additional side movement video-capture and 2D-kinematic analysis was performed (Niessen et al. 2003 & 2004).

Results

Speed-Jumper reached above average high velocities (v) in run-up (v_{max} > 10.4 m s^{-1}) and performed flat phase-jumps with short transition contact times (< 110 ms) to hop (H) and step (S). Power-Jumper obtained high v_{max} (~ 10.2 m s^{-1}) too and solved steep take-offs to H resp. jump (J), therefore with higher center of mass in flight phases and lower hip- and knee-angles during transition phases (Trans) of hop-step and step-jump. Twin-Arm-Jumper performed the superior coordinative dual-arm-kick-technique with v_{max} < 10.0 m s^{-1} as well as flat take-offs and flight phases. Between technique alternatives there were high significant differences in v_{max}, CVP-15 to 0m and TOP_H ($p \le 0.001$) as well as TOP_S ($p \le 0.05$) (Tab. 1).

CVP	v (m s^{-1})		run-up					board	TOP_H	Trans	TOP_S	Trans	TOP_J
	eff. D. (m)	v_{max}	15 m	10 m	5 m	2 m	1 m	0 m	+0.5 m	H-S	+0.5 m	S-J	+0.5 m
[a]SpJ n=5	17.4±0.2	10.6±0.1	10.3±0.0	10.5±0.1	10.5±0.1	10.3±0.1	10.1±0.1	10.0±0.1	9.9±0.1	8.9±0.2	8.8±0.2	7.8	7.8
[b]PoJ n=13	16.8±0.3	10.1±0.1	9.7±0.2	10.0±0.1	10.1±0.1	10.0±0.1	9.9±0.1	9.8±0.1	9.7±0.1	8.7±0.2	8.6±0.2	7.3±0.3	7.2±0.3
[c]TwJ n=9	17.4±0.2	9.9±0.1	9.4±0.1	9.7±0.1	9.8±0.1	9.7±0.1	9.7±0.1	9.6±0.1	9.5±0.1	8.7±0.1	8.6±0.2	7.7±0.4	7.6±0.5
Δ		ab*** ac***	ab*** ac*** bc***	ab*** ac*** bc***	ab*** ac*** bc***	ab*** ac*** bc***	ab*** ac*** bc***	ab*** ac*** bc***	ab** ac*** bc***		ac*		
	p≤0.001***	p≤0.01**	p≤0.05*		significant difference (according to Mann-Whitney)								

Tab. 1: CVP of three male top level TJ (effective dist. 17.1±0.4 m) as representatives of above mentioned technique alternatives during run-up, Trans as well as take-off positions (TOP) of H, S and J

Although there were slight sig. correlations of v_{max} resp. CVP H-S and effective distance (official plus toe-to-board) in ♂ and ♀ TJ ($p \le 0.05$) of national and elite level (Niessen et al. 2003), we retrieved any sig. coherences (according to Spearman) between v_{max}, CVP-indices and effective distance in above mentioned top level TJ, but found selected sig. positive correlations ($p \le 0.05$) for S&v_{max} and J&CVP-board in SpJ, for H&CVP-5m and J&CVP S-J resp. TOP_J in PoJ and for J&CVP S-J in TwJ as well as sig. negative corr. ($p \le 0.05$) for S&CVP S-J in PoJ and H&CVP-board in TwJ.

Discussion/Conclusion

The achieved distances in triple jump TJ strongly depend upon available horizontal velocity in run-up in general and each of the take-offs in particular. Like Hay & Miller (1985) and Brüggemann (1990) we found no evidence in coherence of v_{run-up} and eff. D. in top level athletes, but sig. links of CVP-board, TOP resp. Trans to phase distances (PD) with specific relevance in above mentioned technique alternatives. SpJ need high v_{max} and v_{board} to achieve larger PD in H and finally J as well as to compensate speed drops in S and J. Due to above mentioned technical aspects PoJ suffice higher CVP-5m and little speed drop in Trans H-S and TOP_J to reach mainly larger H and J. TwJ achieve improved H and J dist. with lower v_{board} and by little speed drop in Trans S-J. In conclusion results point out the necessity to analyse movement and velocity pattern of elite TJ more individual to customise training and finally performance.

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