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EXPERIMENTAL SYSTEM FOR THE ANALYSIS OF THE STANDING LONG JUMP

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Abstract: *In this paper we propose a system that helps the trainers / teachers evaluate and improve the performance of athletes / students while performing the standing long jump. Using this system, we aim to find a series of geometric and kinematic parameters (angles, velocities, accelerations) which are important when performing the standing long jump. Based on these parameters, the trainer / teacher should be able to find eventual flaws in the performance of the jump (these flaws being significantly harder to observe just by the naked eye), helping them to easily correct them.*
Keywords: *athletics, motion analysis, standing long jump*

1. INTRODUCTION

The standing long jump is an athletic event which was an Olympic event until 1912. Unfortunately, the popularity of indoor arenas slowly aided in the disappearance of standing long jump as a popular athletic event at competitions, nowadays only Norway being the only country where the standing long jump is a national championship event [6]. This does not mean that the standing long jump has lost all its importance in today's sports; regular long jump the athletes often perform the standing long jump for training, as some of the characteristics of the performance help them prepare better for the regular long jump. Also, in primary school and even high school, the standing long jump can be found as a graded event in sports classes, the main reason being that most (non-sports focused) institutions of learning do not offer the conditions (athletics track, sand box etc) for the students to be able to perform the regular long jump.

2. MEANS AND METHODS

The system which can provide the parameters described above should also be not very expensive (we're thinking primary school budgets should afford them), easy to install and use, ideally portable and sufficiently precise so that the flaws / bad tendencies in the performances of the standing long jump should be easily identified.
The system which we propose uses a video camera (a regular video camera able to deliver 30+ frames per second is usually enough for a decent analysis, if more details are needed, a high speed camera performs better), a free software application and a computer (ideally, a laptop computer, because of the portability). Considering the fact that the most important part of the performance is the take-off (the athlete cannot do much to improve the performance of the jump while in air), the camera is installed perpendicularly to the direction of the jump, at a height of 1 to 1.5 meters from the ground and 2.5 to 4 meters to the subject, so that it captures the motion of the performers from the side. While not always necessary, markers were installed at the main joints of the athletes. We used markers for ankle, knee, hip, elbow and shoulder – more or less can be used, depending on the parameters of interest.
As software, we used a free application called Kinovea (www.kinovea.org) which helped us track all the angles we needed and also find the kinematic parameters we wanted (velocities, accelerations). The application is easy to use and some of the analysis can be made on the spot (on the athletic field) so that direct corrections can be applied to the performance of athletes / students [4].
Firstly, we analyzed the jump of Byron Jones, an NFL player, the current World Record holder, who recorded a jump of 3.73 m at the NFL Combine on 23 February 2015 [5]. The video which we used can be found on NFL's Youtube Channel (https://www.youtube.com/watch?v=n0UeHxglMJ4).

Figure 1: Angles for the jump of the best performer in the world

For the parameters used, we have chosen 5 angles. The first 3 angles belong to the starting (preparation) posture before the jump: the angle between the inferior and the superior part of the leg (the knee angle), the angle between the upper body and the leg (the hip angle) and the angle between the upper body and the ground. The last 2 angles are the angle between the legs and the ground at take-off (the take-off angle) and the upper body and the leg in mid air (the hip angle in mid air). All of these angles were set as reference parameters for the "ideal" jump, also scientific literature was also used in order to set thresholds for these parameters, in some cases, aiming to compare other athlete's performances to them and correct where needed [1][2][3].

3. RESULTS

We had 16 amateur performers (high-school students, aged about 17) which had markers (made of common paper) installed on their ankle, knee, hip, elbow, shoulder. The standing long jump performance was recorded using a Sony Cybershot DSC-QX10, placed on a tripod, four feet from the jumper, orthogonally to the direction of motion. The camcorder used to record the jump, records the video on a Micro-SD storage card in MP4 format. The MP4 format can be used directly in the Kinovea application.

Figure 1: Angles for the jump of an amateur jumper

We recorded our performers' physical data (height, weight) and then they performed the event. We measured the 5 angles of interest and also the performance of the jump. We compared the angles of interest with those of the World Record holder's, focusing on the relative error between them. We obtained the table below.

Table 1: Comparison between the amateur jumpers' angles and the ideal jumping angles

A*	B*	C*	D*	E*	F*	G*	H*	I*	J*	K*	L*	M*	N*
1	72 kg	183 cm	212 cm	107º	52%	85º	70%	114º	14%	51º	13.3%	49º	8.8%
2	65 kg	168 cm	196 cm	99º	41%	66º	32%	105º	5%	50º	11.1%	102º	126.6%
3	70 kg	172 cm	180 cm	100º	42.8%	73º	46%	109º	9%	48º	6.6%	81º	51.4%
4	67 kg	180 cm	208 cm	95º	35.7%	61º	22%	98º	-2%	47º	4.4%	63º	40%
5	76 kg	180 cm	185 cm	90º	28.5%	64º	28%	106º	6%	51º	13.3%	80º	77.7%
6	71 kg	163 cm	210 cm	100º	42.8%	94º	88%	123º	23%	51º	13.3%	70º	55.5%
7	58 kg	178 cm	221 cm	103º	47.1%	73º	46%	102º	2%	47º	4.4%	74º	64.4%
8	56 kg	170 cm	185 cm	95º	35.7%	57º	14%	99º	-1%	52º	15.5%	79º	75.5%
9	54 kg	168 cm	182 cm	91º	30%	74º	48%	112º	12%	51º	13.3%	63º	40%
10	75 kg	175 cm	150 cm	105º	50%	71º	38.1%	108º	8%	55º	22.2%	71º	57.7%
11	82 kg	177 cm	170 cm	101º	44.2%	82º	64%	112º	12%	55º	22.2%	74º	64.4%
12	98 kg	181 cm	123 cm	105º	50%	44º	-2%	83º	-17%	55º	22.2%	80º	77.7%
13	67 kg	164 cm	175 cm	122º	74.2%	78º	56%	103º	3%	54º	20%	105º	133.3%
14	79 kg	170 cm	180 cm	118º	68.5%	66º	32%	93º	-7%	52º	15.5%	65	44.4%
15	63 kg	164 cm	197 cm	108º	54.2%	46º	0%	83º	-17%	54º	20%	85	88.8%
16	65 kg	175 cm	257 cm	86º	22.8%	42º	0%	92º	-8%	45º	0%	37	-6.6%

A = Subject number
B = Subject weight
C = Subject height
D = Jump performance
E = Knee angle
F = Relative error for the knee angle, considering the angle of reference at 70 degrees
G = Hip angle
H = Relative error for the hip angle, considering the angle of reference between 45 and 50 degrees
I = Angle between the upper body and the ground
J = Relative error for the angle between the upper body and the ground, considering the angle of reference at 100 degrees
K = Take-off angle (probably the most important angle)
L = Relative error for the take-off angle, considering the angle of reference at 45 degrees
M = Hip angle in air
N = Relative error for the hip angle in air, considering the angle of reference between 40 and 45 degrees

3. CONCLUSIONS AND FUTURE WORK

The system which we proposed performed very well and we were able to obtain the angles of interest for all the subjects in the study. The recordings were performed at a high-school, so we can say that one of our aims for practical applications was met. We also want to note that the system's use should not be limited to the standing long jump, but any athletics / sports event which can be efficiently observed from the side: regular long jump, standing high jump, basketball throwing, soccer free kicks, physical training exercises like squats, push-ups and more.

The study's results, considering there were only amateur high-school students involved, were as expected: significant differences in performance parameters. The sample of 16 performances is too low to be taken as a standard, but it can be easily seen that the subjects who were close to the ideal angles (see subject 16) also had better performances. More data analysis is needed, on bigger samples, to be able to confidently say which of these angles matter more for the performance of the standing long jump. Also, a lot of aspects were not taken into consideration; we're also interested in the correlation between the height, weight and the performance and also to see if any important differences in velocities / accelerations appear during the performing of the jump, all of these being subject of our future work.

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