VALIDITY AND RELIABILITY OF THE MICROSOFT KINECT TO OBTAIN THE EXECUTION TIME OF THE TAEKWONDO'S FRONTAL KICK

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The aim of this study was to verify the validity and reliability of the Microsoft Kinect® as a tool to analyze the time of the frontal kick of the Taekwondo (*ap chagui*). The volunteers performed 15 repetitions of this kick while the execution time data was been obtained, simultaneity, by the Microsoft Kinect® and the OptiTrack System (golden pattern). In order to verify the reliability of the durations of the kicks we calculated the Intraclass Correlation Coefficient ($ICC_{3,k}$) between execution times found for each system. The Pearson Correlation was used to test the concurrent validity. The results of ICC and r Pearson presented in this study indicate that the Microsoft Kinect®, associated with a tracking algorithm, could be a feasible tool to evaluate the execution time of the frontal kick of the Taekwondo (*ap-chagui*).

KEYWORDS: 3d kinematics analysis, markerless motion capture, martial arts.

INTRODUCTION: Taekwondo (TKD) is a Korean martial art and is an Olympic sport since 2000 and its mainly characteristic is the usage of kicks to hit the opponent in the trunk or in the head (Vieten et al., 2007). Since the execution time and the velocity are report in the literature as the determinant variable to the hit success (Jakubiak & Saunders, 2008 and Falco et al., 2009), to obtain it is important to planning and evaluate the training programs (Leichtweis et al., 2012). In order to obtain these variables the best method is the 3D kinematic analysis and it use multiple high speed cameras and some retro-reflexive markers were fixed in the subject (Baker, 2006). Many commercial systems are available to obtain 3D kinematic data (Vicon, MAC System), however they were expensive and cumbersome (Clark et al., 2012). Recently, some studies using the Microsoft Kinect® (Microsoft, EUA) have been presented as an inexpensive and portable solution to perform the motion analysis (Preis et al., 2012; Clark et al., 2012; Sung et al., 2011; Gabel et al. 2012). The Microsoft Kinect® combines the utilization of a camera and an infrared sensor to create a 3D body model (Mentiplay et al., 2013). In order to improve the Microsoft Kinect® to motion analysis some automatic recognition algorithms were proposed in the literature, making this a useful tool for real time analysis (Vieira et al., 2014; Sung et al., 2011). Nowadays, these algorithms have been applied to monitoring the elderly daily living activities, surveillance and the interaction between man and robot (Vieira et al., 2014, Elgendi et al., 2012). Despite the high accuracy of the sensor Microsoft Kinect® to perform a pattern recognition already found in previously work (Vieira et al., 2014), none of them was applied specifically with the purpose to record the duration and the number of trials of different action performed. So, the aim of this study was to investigate the validity and reliability of the Microsoft Kinect®, to obtain the execution time of the frontal kick of the Taekwondo (*ap chagui*). This system could become a monitoring tool and could be used to control the load in the training, allowing to quantify the duration of each activities. Another advantage could be the usage of a valid and reliable tool that will allow the coach to have a systematic record of all training sessions, and so, to make the relationship between the performance of athletes and what was trained and the consequent adjustment in the futures plans.

METHODS: We analyzed four highly trained (5.75 ± 2.63 years of practice) Taekwondo athletes (18.25 ± 2.22 years) from the Sports Training Center from the Federal University of Minas Gerais (CTE-UFMG).
After a warm up, the athlete was asked to perform the frontal kick (*ap chagui*) with the right leg. The initial condition was with the kicking foot in front of the support limb. They performed 15 sequential repetitions in two velocities 3.00 m.s^{-1} (slow) and 8.00 m.s^{-1} (fast).
The kick was recorded simultaneously by the Optitrack 3D kinematic system (NaturalPoint, EUA), defined as golden pattern, and by the Microsoft Kinect® (Microsoft, EUA). Eighteen optoelectronics cameras (Prime 17w, 360Hz, field of view 70^{o} and resolution 1.7 MP) were positioned around the athlete. The 3D coordinates of the third metatarsal of the right leg was obtain as a function of time. The one camera (30Hz and resolution 0.3MP) of the Microsoft Kinect® was positioned in the sagittal plane. In order to obtain automatically a point to represent the foot of the athlete we used the 20 anatomic points estimated in the athlete body acquired by Kinect and a routine developed in the Visual Studio Ultimate 2013 (Microsoft, EUA).

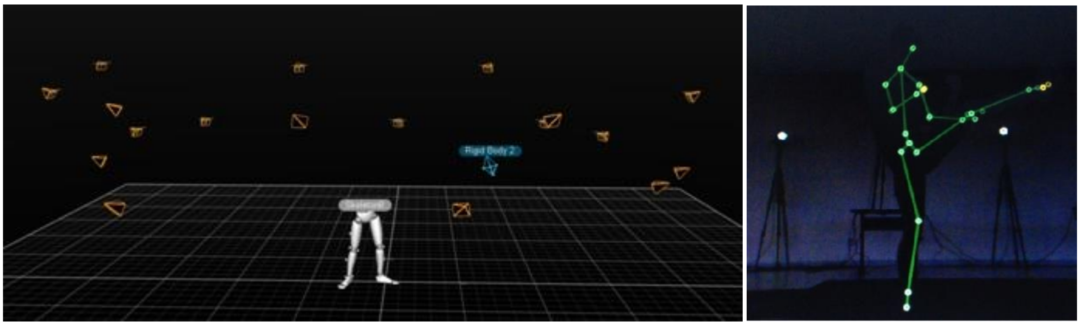

Figure 1: Images of the acquisition setup of both systems (Optitrack and Kinect)

The execution time of each kick was calculated using the data obtained by each system. In order to verify the reliability of the durations of the kicks we calculated the Intraclass Correlation Coefficient ($ICC_{3,k}$) between execution times found for each system. The ICC of the variables of the simultaneous measurement was calculated by the means of the variables of the set of 15 kicks. Paired t-test was applied to compare the duration kicks obtained by Microsoft Kinect® and OptiTrack systems. The Pearson Correlation was used to test the concurrent validity. All statistical procedures were calculated by SPSS 18.0 with a $p<0.05$.

RESULTS: Table 1 shows the mean and standard deviation of the execution time by Microsoft Kinect® and Optitrack system and the results of the paired t-test with the effect size.

Table 1
Descriptive statistics of execution time (s) by Microsoft Kinect® and Optitrak and results of paired t-test (p value)

Velocities (m.s^{-1})	Microsoft Kinect (Mean±sd)	Optitrack (Mean±sd)	p value
Slow	1.89±0.88	1.97±0.72	0.521
Fast	0.67±0.13	0.72±0.08	0.002

In order to verify the reliability of the execution time (s) by Microsoft Kinect®, ICC was determined and is shown in table 2.

Table 2
Intraclass Correlation Coefficient ($ICC_{3,k}$) for the kick time in Microsoft Kinect®

Velocities ($m.s^{-1}$)	$CCI_{(3,k)}$	Valor p
Slow	0.992	0.001
Fast	0.971	0.001

The concurrent validity, between the two systems was analyzed by correlation analysis and the results are shown in the table 3.

Table 3
Concurrent validity accessed by Pearson correlation coefficients (r) between the two systems

Velocities ($m.s^{-1}$)	r Pearson	p
Slow	0.937	0.001
Fast	0.829	0.039

DISCUSSION: Previous studies that used the Microsoft Kinect®, to measure some postural control (Clark *et al.* 2012 and Yang et al. 2014) found ICC values raging from 0.66 to 0.94. The results of ICC of the Microsoft Kinect®, presented in table 2, indicate very high reliability for the determination of durations of the kicks (*ap chagui*).
Related to the concurrent validity between the systems (table 3) we found in the this study high and significant values for the fast and slow kick, however the mean values of the fast kick obtained by the Kinect were significantly different of the values obtained by the Optitrack. This fact shows the limitation of the Kinect to analyze fast movements, since it acquire the data in a low frequency (30Hz). However, is important to highlight that besides the difference between the systems the Kinect was effective to measure the duration time and the number of repetitions of the kick.

CONCLUSION: The results presented in this study indicate that the Microsoft Kinect®, associated with a tracking algorithm, could be a feasible tool to evaluate the execution time of the frontal kick of the Taekwondo (*ap chagui*).These results associated with low cost, simplicity and the possibility to use in different environments could highlight the possibility to apply the Kinect to analyze the sport movements and quantify the load of the training.

REFERENCES:
Baker, R. (2006). Gait analysis methods in rehabilitation. *Journal of neuroengineering and* rehabilitation, 3, 4.

Clark, R., Pua, Y., Fortin, K., Ritchie, C., Webster, K., Denehy, L., & Bryant, A. (2012). Validity of the Microsoft Kinect for assessment of postural control. *Gait & Posture*, 36, 372–77.

Elgendi, M., Picon, F., & Magnenat-Thalmann, N. (2012). Real-time speed detection of hand gesture using kinect. *Proceedings of the Autonomous Social Robots and Virtual Humans Workshop, 25th Annual Conference on Computer Animation and Social Agents*.

Falco, C., Alvarez, O., Castillo, I., Estevan, I., Martos, J., Mugarra, F., & Iradi, A. (2009). Influence of the distance in a roundhouse kick´s execution time and impact force. *Journal of Biomechanics*, 42, 242-48.

Gabel, M., Gilad-Bachrach, R., Renshaw, E., & Schuster, A. (2012). Full body gait analysis with Kinect. *Proceedings of the 2012 Annual International Conference of the IEEE*, 964-967.

Jakubiak, N. & Saunders, D. (2008). The feasibility and efficacy of elastic resistance training for improving the velocity of the Olympic taekwondo turning kick. *The Journal of Strength & Conditioning Research*, 22, 4, 1194-97.

Leichtweis, M., Antunez, B., Xavier, B., & Vecchio, F. (2012). Efeitos de diferentes protocolos de treinamento no tempo para executar chute no taekwondo. *Arquivos de Ciência do Esporte*, 1, 1, 37-45.

Mentiplay, B., Clark, R., Mullins, A., Bryant, A., Bartold, S., & Paterson, K. (2013). Reliability and validity of the Microsoft Kinect for evaluating static foot posture. *Journal of Foot and Ankle Research*, 6, 14.

Preis, J., Kessel, M., Werner, M., & Linnhoff-Popien, C. (2012). Gait recognition with kinect. Proceedings of the 1st International Workshop on Kinect in Pervasive Computing.

Sung, J., Ponce, C., Selman, B., & Saxena, A. (2011). Human activity detection from rgbd images. Prodeedings of the AAAI workshop on Pattern, Activity and Intent Recognition (PAIR), 64.

Vieira, A., Nascimento, E., Oliveira, G., Liu, Z., & Campos, M. (2014). On the improvement of human action recognition from depth map sequences using Space–Time Occupancy Patterns. *Pattern Recognition Letters*, 36, 221–27.

Vieten, M., Scholz, M., Kilani, H., & Kohloeffel, M. (2007). Reaction time in taekwondo. *Proceedings of the 25th International Symposium on Biomechanics in Sport*, 293-96.

Yang, Y., Pu, F., Li, Y., Li, S., Fan, Y., & Li, D. (2014). Reliability and Validity of Kinect RGB-D Sensor for Assessing Standing Balance. *IEEE Sensors Journal*: 14, 5, 1633-38.