The 18th International Scientific Conference
eLearning and Software for Education
Bucharest, May 12-13, 2022
10.12753/2066-026X-22-089

THE TRANSITION FROM JUNIOR TO SENIOR IN HANDBALL: ESTIMATING THROWING ACCELERATION WITH A PORTABLE DEVICE

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Abstract: *Understanding the upper-arm-specific acceleration in handball is critical for both game performance and career transitioning. The transition from junior to senior status is regarded as a watershed moment in an athlete's career. The trajectory of a young athlete's sports career is determined by how well they respond to the demands of this process. The number and speed of throws have a large impact on the upper-arm-specific acceleration. However, due to technological limitations, it is difficult to quantify the impact the number and speed of throws in handball has over career transitioning. The trajectory of a young athlete's sports career is determined by how well they respond to the demands of this process. As a result, the goal of this research was to identify a novel method for estimating throwing speed in handball using a low-cost accelerometer-based device. A total of 70 handball players across 6 teams performed throws while wearing the accelerometer to measure wrist acceleration and throwing speed. The statistical analysis showed consistency and visual differences in data between teams. These detected differences mean that the device can be used to compare the current performance of a youth player to a senior and, if major differences are observed, to modify, correct or alter the training of the player in such a way to ensure a development that would raise the youth player to the values of the senior, therefore allowing for a successful transitioning.*

Keywords: *wearable sensors; handball; transition; overarm throw; acceleration.*

INTRODUCTION

I. Accelerometery and career transitioning in handball

The transition from junior to senior status is regarded as a watershed moment in an athlete's career. The trajectory of a young athlete's sports career is determined by how well they respond to the demands of this process [1]. Young people who aspire to a higher level must deal with multiple transitions in all aspects of their personal lives at the same time [10; 13; 16; 23]. Athletics and non-athletics are a real challenge and complicate the entire process [16]. If the transition period lasts several years, the process becomes even more difficult due to the uncertainty and changes that occur [17].

The prevalence and incidence of transitioning problems are a worrying situation in handball [10]. To understand why and how such problems occur, it is important to investigate the pathways between transitioning and training outcomes [13]. Mistakes in training load are an example of a pathway that is usually linked to a failed transition to a professional handball career [23].

Throwing speed is the most important performance variable in handball, and jumping is the most common technical procedure, accounting for more than 75% of all throws [20]. Many researchers have been interested in throwing speed in the sport of handball over the years. [4] found that the accuracy of the throw and the speed of the ball play a significant role in scoring a goal when studying the biomechanical aspects of throwing in the game of handball. [3] and [18] have previously presented the same conclusion, confirming that scoring a goal requires both throwing speed and accuracy.

There have been studies that looked at the rate of throw from a biomechanical standpoint [21]. Other studies have compared throw rate by gender [11] made the analysis on different levels of performance [9], but very few have addressed this topic during an official match. Most studies have been conducted under pre-controlled, controlled training conditions that are very different from actual game situations [19].

1.1. Wearable accelerometers

The accelerometer detects physical manifestations of force on the device, such as acceleration and deceleration in uni - or multi-axial movements. The characteristics and applicability of the accelerometer's many peculiarities vary [24]. Following optimization for automotive applications, further miniaturization enabled adaptation to other sectors, such as biomedical and consumer electronics. Previous research described the devices as dependable [24], with continuous accuracy improvements [7].

The accelerometer collects data in multiple dimensions, including the actual x-, y-, and z-axial forces with a time stamp, as well as further processed data. In the past, the data showed a lack of accuracy, particularly in complex, dynamic motions [2,6,12]. Most today's wearable devices include tri-axial tracking with a sampling frequency of 100Hz. Attaining this level of maturity allowed these devices to be used in human motion analysis [8,15].

Later studies [5,14] claimed acceptable levels of intra- and inter-unit reliability. The most recent study, which took place in a mechanical test setting, confirmed the intra-unit reliability.

As a result, [22]'s argument that an appropriate methodology for quantifying movement is currently lacking may still be valid. Furthermore, the identified issue of missing reliability is still present in the most recent tests [15].

II. RESEARCH DESIGN

2.1. Aim

Our focus for this study was set on identifying a reliable and easy-to-use method of measuring the handball standing throw acceleration that can be implemented in the training and development of youth players to ensure a proper transition towards professional teams through a controlled and balanced learning process.

2.2. Subjects

We recruited a total of 70 handball players from 6 teams: 4 were youth and 2 were professional. There were 23 youth female subjects, ages 16±1, and 13 adult female subjects, ages 21+. At the same time, the study included male subjects: 10 adults, ages over 19, and 24 youth, ages 16±1.

2.3. Materials

For this study we used the MbientLab MetaMotionS sensor kit for biomechanical analysis (figure 1). The sensor is a clinical grade solution designed to be used as a wrist worn device that provides recorded and real-time data.

It incorporates various sensors that can be used separately or at the same time during a measurement: accelerometer, gyroscope, magnetometer, IMU sensor, temperature sensor, barometer, ambient light detector.

Figure no. 1. MbientLab MetaMotionS sensor kit

The data collection was performed through the MetaWear iOS app that was developed by the MbientLab team (figure 2).

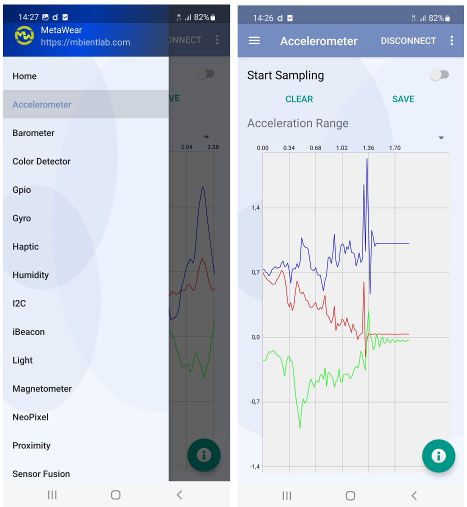

Figure no. 2. MbientLab MetaWear iOS app screenshots

2.4. Testing protocol

All trials were performed in each team's training hall. Each subject had to follow a standardized warm-up, each participant performed a total of 5 throws and the best of the 5 was kept. The distance we selected for the throw was the 7 meter penalty kick line on the handball court.

The accelerometer was positioned at each of the subject's wrist using the device's own watch-belt. We made sure that the orientation of the sensor was always the same and consistent with either left-handed or right-handed players.

The type of throw we selected was the standing overarm throw. The shooting arm already prepared before the start of the recording, making sure the ball was above the subject's head. We hoped that through this style of throw to ensure a consistent pattern of accelerations across all ages, levels of performance and power output.

2.5. Results

The collected data was analysed with SPSS 17 software. The average acceleration for each subject was calculated and then descriptive statistical analysis was conducted for each of the 6 teams. For ease of work we've used the following abbreviations of each variable: AvgAcc means average acceleration, the x, y and z are each of the 3 axis of motion and T followed by a number is a team's code.

No statistical test for comparing the means of the 6 teams was conducted because the aim of this study was not to identify any statistical difference that might appear between the teams (such difference would be expected considering the age and training gap between some of the teams), but to show that this type of device can offer reliable information across a wide range of unique handball squads.

The reason for analysis the average acceleration values was based on the aim of this study. We didn't pursue the peak performance of the players but to test the device in the context of its future integration as a tool that would contribute to youth-to-senior transitioning. Therefore, both negative and positive values were compiled and analysed. As a result, values that tend towards 0 indicate a better performance of the players and teams respectively.

	N	Minimum	Maximum	Mean	Std. Deviation
AvgAcc_X_T1	11	-0.63	0.89	-0.03	0.45
AvgAcc_X_T2	12	-0.45	0.70	0.09	0.39
AvgAcc_X_T3	12	-0.90	0.59	-0.28	0.60
AvgAcc_X_T4	12	-0.56	0.44	0.01	0.29
AvgAcc_X_T5	13	-1.11	0.91	-0.03	0.56
AvgAcc_X_T6	10	-0.80	0.96	-0.09	0.57

Table no. 1. Descriptive statistics for the average acceleration on the x axis for the 6 teams

As far as the anterior-posterior axis of movement is concerned, we didn't have any major variations of standard deviation among the 6 teams. The data for team no. 4 (M=0.01, SD=0.29) is the lowest of the six because it is the adult male professional team. Even though their results are way outside the range of the others, this is to be expected considering the fact that the players are not geographically bound, but are selected from a wider area based on their handball experience and performance.

Considering that we were expecting major fluctuations of data between the groups, the fact that for the x-axis of movement the acceleration values do not present such a dynamic may indicate that this device can be used as a learning/teaching tool.

	N	Minimum	Maximum	Mean	Std. Deviation
AvgAcc_Y_T1	11	-2.32	2.85	-0.52	1.86
AvgAcc_Y_T2	12	-1.60	1.45	0.02	1.14
AvgAcc_Y_T3	12	-2.65	1.57	-0.30	1.55
AvgAcc_Y_T4	12	-2.14	1.52	0.30	1.32
AvgAcc_Y_T5	13	-1.71	2.60	0.07	1.48
AvgAcc_Y_T6	10	-2.22	1.75	-0.48	1.72

Table no. 2. Descriptive statistics for the average acceleration on the y axis for the 6 teams

The lateral acceleration data (table 2) indicate a slight fluctuation increase compared to the x-axis of movement. This is explained by the complex biomechanics of the upper arm throw technique. All 3 major joints of the upper arm are involved in twisting and rotation motions during the throw, even though it might not be evident at such high speeds of execution. Nevertheless, this analysis is concurrent in terms of variation with the anterior-posterior results.

	N	Minimum	Maximum	Mean	Std. Deviation
AvgAcc_Z_T1	11	-1.97	-0.46	-1.30	0.43
AvgAcc_Z_T2	12	-0.95	-0.35	-0.58	0.19
AvgAcc_Z_T3	12	-1.41	0.39	-0.65	0.49
AvgAcc_Z_T4	12	-1.10	0.07	-0.49	0.32
AvgAcc_Z_T5	13	-0.88	0.03	-0.49	0.26
AvgAcc_Z_T6	10	-0.83	0.21	-0.42	0.36

Table no. 3. Descriptive statistics for the average acceleration on the x axis for the 6 teams

The last analysis was conducted on the vertical acceleration data. This batch of data indicates that the device can detect ever so subtle vertical movements during the throw. We've tried, with the type and style of throw picked for this study, to minimize the up-and-down motion with the secondary aim to identify possible errors or deviations regarding throwing technique. The acceleration detected on this axis of movement, even though consistent in its values of variation, may point to possible errors in learning and consolidating this throwing technique.

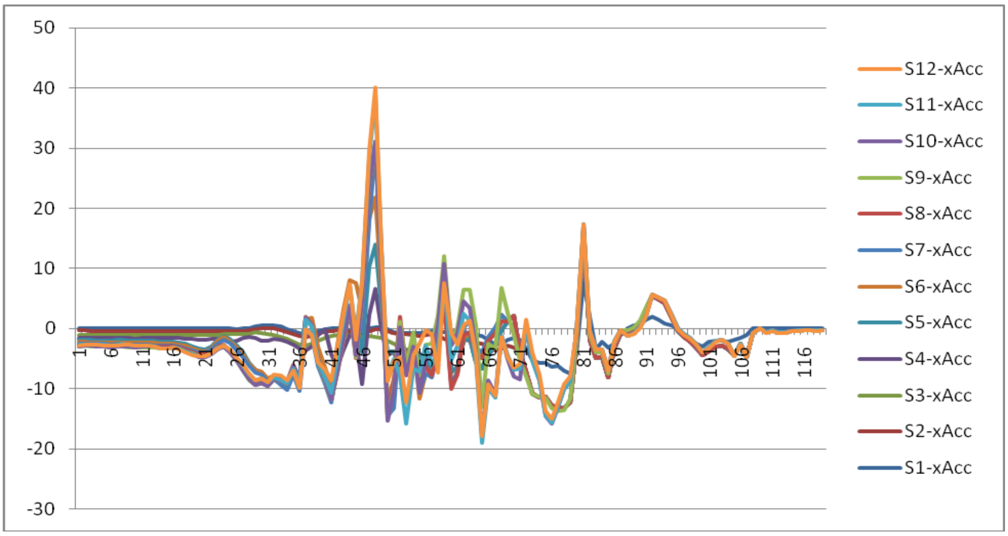

Figure no. 3. Plot of x-axis acceleration for each of team 3's players of the study (youth male)

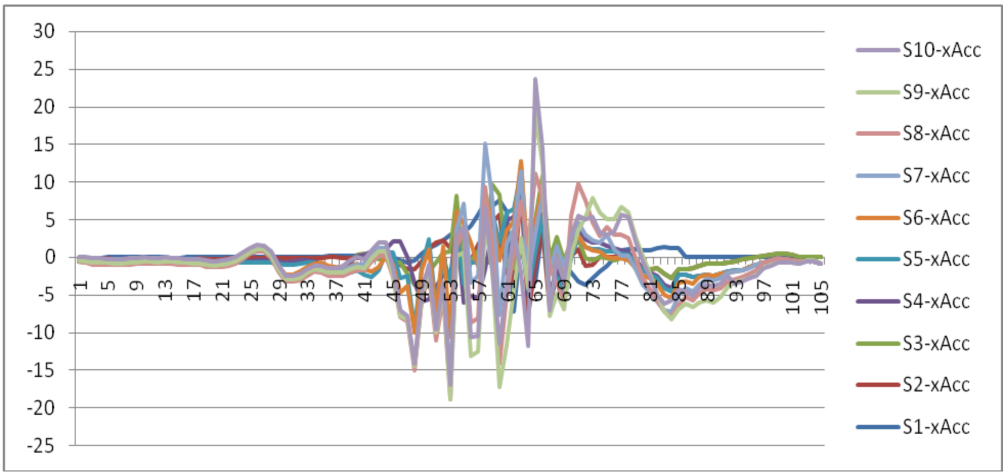

Figure no. 4. Plot of x-axis acceleration for each of team 4's players of the study (senior male)

Further analysis of the data was conducted in the form of plotting it into graphs for a visual evaluation. When we are to compare the data collected from a youth team versus the senior one, we can identify some differences. These differences can be a result of a variety of factors (age, training, experience, technique) but at the same time it allows us to see that there are differences regarding the x-axis acceleration between the two groups. The youth team (figure 3) reaches peak acceleration much sooner during the throw compared to the seniors (figure 4). Moreover, the plot for the latter is much more "noisier" compared to the former. This may be a result of the heterogeneity of the professional team compared to the youth one. These detected differences mean that the device can be used to compare the current performance of a youth player to a seniors and, if major differences are observed, to modify, correct or alter the training of the player in such a way to ensure a development that would raise the youth player to the values of the senior, therefore allowing for a successful transitioning.

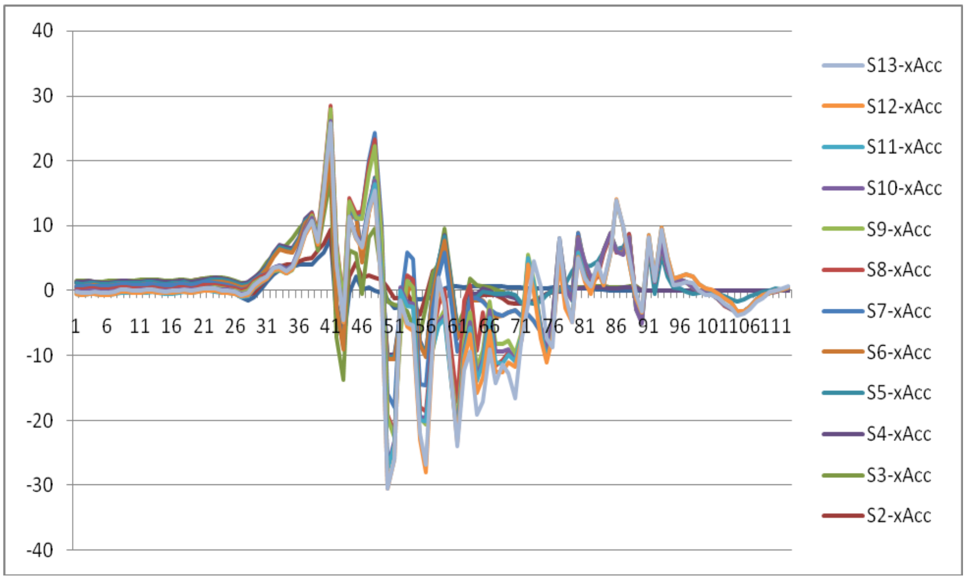

Figure no. 5. Plot of x-axis acceleration for each of team 5's players of the study (senior female)

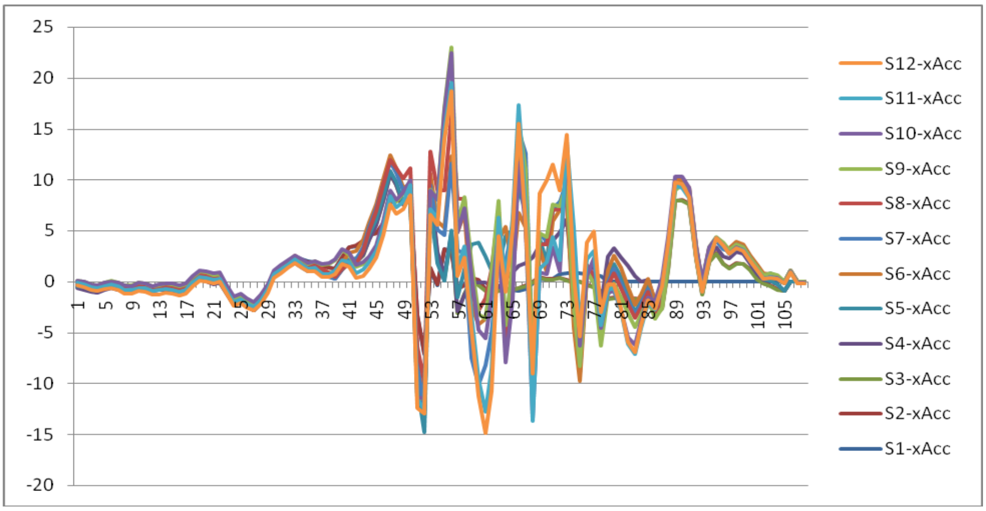

Figure no. 6. Plot of x-axis acceleration for each of team 5's players of the study (youth female)

The same visual difference can be observed with regards to the women teams, between the senior and youth ones (figure 5 and 6).

III. CONCLUSIONS

The results of the current study showed that using MbientLab MetaMotionS, the data collected from the accelerometer accurately estimated throwing acceleration in both youth and senior handball players. Instead of using a motion capture method to assess overarm throwing velocity, a small and inexpensive wrist mounted accelerometer could be used in handball. More research is needed to quantify overarm activities in handball, such as blocking, defensive contact, passing, and shooting. As a result, the accelerometer-based data collected may provide an effective detection of possible differences between youth and senior players and encourage an active monitoring of the youth player's development and potentially avoiding a risky transitioning. In the future, it appears that determining throwing velocity and twist using a wrist-mounted accelerometer will be a topic in the field.

The goal of this study was to devise a practical and inexpensive method of estimating throwing accelerations in handball. To that end, we created a simple testing methodology that was both well-calibrated (they produced unbiased estimates of the throwing acceleration) and precise (the estimate errors were small). Including sex and performance level – both individually and as part of a team – appeared to display differences in the data plotting model precision. As a result, the proposed device and testing methodology have the potential to provide a reliable method for estimating throwing accelerations in handball as a tool for controlling the development of youth towards a successful transition to professional teams.

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