The main contribution of this study was the continuous measurements of gait biomechanics, heart rate and ROF during half-marathon. Perceived fatigue during endurance running seems to be associated with higher gait variability and lower variability of heart rate. The results of this work will be extended further via statistical testing.

REFERENCES:
[1] Folland et al., Med Sci Sports Exerc, 2017
[2] Jewell et al., J. Sports Sci ,2017
[3] Morin et al., Med Sci Sports Exerc, 2011
[4] Gronwald et al., Front physiol, 2018
[5] Micklewright et al., Sports Med, 2017
[6] Falbriard et al, Front physiol, 2018
[7] Kumar et al., CRC Press, 2016
[8] Edwards et al., AEMB, 1995
[9] Mourot et al., Eur. J. Appl. Physiol., 2004

ESTIMATION OF INSTANTANEOUS SPRINT VELOCITY WITH A WEARABLE GNSS-IMU SENSOR USING A SENSOR FUSION APPROACH

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INTRODUCTION:
Power-Force-Velocity profile obtained during the sprint test is crucial for designing personalized training and evaluating injury risks [1]. Predominant method of estimating the instantaneous velocity [2] assumes it to have a first order exponential behavior. While this method provides ease of use, the sprint velocity profile for all athletes may not show an exponential behavior. Alternately, velocity profile can been estimated using inertial sensors [3], with a speed radar, or a smartphone application [4]. However, [3] requires timing gates for drift removal while [4] provides only the mean speed. Thus, there is a need for a wearable sensor-based velocity estimation algorithm for the sprint test. The proposed method solves this problem using a sensor fusion approach, by combining the signals from wearable GNSS and IMU sensors.
METHODS:
To develop and validate our algorithm, we collected data from nine elite sprinters equipped with a wearable GPS-IMU sensor (Fieldwiz), who ran two trials each of 60m and 30m/40m sprints. In our algorithm, we utilized a gradient descent-based filter [5] as an orientation filter, which simplified our model to a linear one-dimensional model, thus allowing us to use a simple Kalman filter (KF) as a velocity/acceleration filter. We used two cascaded KFs, first to segment the sprint data precisely, and subsequently to estimate the velocity during sprinting and the sprint duration. We validated the estimated velocity and duration with speed radar and photocell data as reference.
RESULTS:
The mean percentage error of the estimated velocity w.r.t the radar speed profile ranged from 6% to 8%, while that for the estimated sprint duration lied between 0.1% to -6%. In case of the maximum velocity, the Bland-Altman plot showed close agreement between the estimated and the reference values, with all the values lying between two standard deviations. Examination of fitting errors indicated a second order exponential behaviour for the sprint velocity profile, unlike the first order behaviour previously suggested in literature.
CONCLUSION:
The proposed sensor-fusion algorithm has been validated to compute an accurate velocity profile with respect to the radar; it can compensate for and improve upon the accuracy of the individual IMU and GNSS velocities. This method will thus enable the use of wearable sensors in the analysis of sprint functional test.

References:
1. Morin, J. B. et al. (2016) Int J Sports Physiol Perform, 11(2), 267-272.
2. Samozino, P. et al. (2016) Scand J Med Sci Sports, 26(6), 648-658.
3. Setuain, I. et al. (2018) Scand J Med Sci Sports, 28(2), 463-472.
4. Stanton, R. et al. J Sports Med, 2016.
5. Madgwick, S. O. et al. (2011) IEEE ICORR, (pp. 1-7).

ON THE USE OF BEAST ACCELEROMETER FOR BARBELL VELOCITY MEASUREMENT IN THE BACK-SQUAT

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INTRODUCTION:
The force exerted by the athlete and the resulting velocity of the movement can be measured via force plates and linear position transducer (LT). Recently, low-priced accelerometers have been used to measure barbell displacement velocity (1). Barbell velocities can be used to generate Force-Velocity profiles (FV) for individual exercises and athletes and used to compute the one repetition maximum (1RM) indirectly (2). 1RM is best estimated with velocities obtained from overloads ranging from 20% to 70% of 1RM (3). “Beast” accelerometer (Beast Technologies S.r.l., Brescia, Italy) is a device widely used and its validity, reliability, and repeatability were tested for loads ranging from 50% to 100% of 1RM only (1). This study aims to analyze the validity and accuracy of the Beast device for the measurement of barbell velocity with loads ranging from 20% to 70% of 1RM and test the accuracy and validity of the 1RM estimate in the back-squat exercise.
METHODS:
18 rugby players (22.0±2.9years, 1.80±0.07m, 87.4±9.2kg) were recruited. 96h after testing their back-squat 1RM directly, players performed five sets of two repetitions with incremental loads ranging from 20% to 90% of their 1RM. Barbell velocity was simultaneously measured using a LT and the Beast accelerometer (BA) (1). To assess accuracy, paired samples t-test and Bland-Altman Plots were used to identify potential systematic bias (1), standard error of the estimate was also used to report the typical error of the measurements compared with the LT. Validity was tested using Pearson’s product-moment correlation coefficient (r) (1). Moreover, BB 1RM and LT 1RM estimate (2) from FV accuracy, via Bland-Altman Plots and one-way ANOVA, and validity were tested in comparison to the 1RM directly assessed.
RESULTS:

The measurements of barbell velocity showed a high correlation between LT and BB (r=0.91, p<0.001, SEE=0.08m/s. No systematic bias was found (p=0.114). Analysis of the linear regression of the Bland-Altman plot showed consistent differences across the whole range of velocities (r2=0.036). The directly assessed 1RM showed a high correlation with both BA 1RM (r=0.826, p=0.001, SEE=10.7kg) and LT 1RM (r=0.876, p<0.001, SEE=9.2kg) estimates, with no systematic bias (p=0.157).

CONCLUSION:

Beast accelerometer is accurate and valid for the measurement of barbell velocity in back-squat across a broader range of loads than previously presented (1). 1RM estimate is also valid and accurate, caution should be used for its application for prescribing of training due to high SEE.

REFERENCES:

1. Balsalobre-Fernández et al. 2017. Analysis of wearable and smartphone-based technologies for the measurement of barbell velocity in different resistance training exercises. Front Physiol 8: 1–10, 2017.

2. Helms et al. 2017. RPE and velocity relationships for the Back Squat, Bench Press, and Deadlift in Powerlifters

3. Pérez-Castilla et al. 2017. Evaluation of Muscle Mechanical Capacities through the Two-load Method

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FIRST-IN-ASIA APPLICATION OF CARDEA 20/20 ECGTM AUTOMATED DIGITAL ECG DIAGNOSTIC SYSTEM: COMPARATIVE ANALYSIS AGAINST CONVENTIONAL ECG IN ELITE ATHLETES

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INTRODUCTION:

Sudden cardiac events secondary to arrhythmias, conduction abnormality, cardiomyopathies and congenital heart disease can have devastating impact on elite athletes. Electrocardiography (ECG) screening is widely performed as a pre-participation assessment for elite athletic training and competition. Most institutions use conventional ECG systems (CON) not specifically designed for athletes. Recently, the Cardea 20/20 digital ECGTM system (Cardea) was developed with automated diagnostic algorithm for athletic use. In this study, we compared Cardea against CON in the machine detection and reporting of ECG parameters commonly interpreted by sports cardiologists.

METHODS:

The study population included elite athletes at the Hong Kong Sports Institute. Twelve-lead 10-second ECG was first recorded by CON (ECG-1350K, Nihon Kohden, Japan) followed immediately by Cardea (Cardiac Insight, Washington, USA) using the same electrode system. ECG data were extracted by physicians. For harmonisation of machine interpretation of Normal versus Abnormal ECGs, we used a Boolean approach to re-classify CON machine-flagged Abnormal ECGs as TRUE and Normal or Borderline ECGs as FALSE, whereas Cardea-specified review of ECGs was kept unchanged as TRUE or FALSE. Quantitative data were analysed using Pearson's correlation and Bland-Altman plot. A statistical level of P<0.05 was considered significant.

RESULTS:

Among 49 elite athletes recruited, 32 (65%) were male with a mean age (±SD) of 23.0±6.8 years (range: 11.0-42.4). 39 (80%) were Asian, 6 (12%) Caucasian/European, 1 (2%) African/Afro-American, 1 (2%) Pacific Islander and 2 (4%) Other. Athletes' sport disciplines classified according to the Sports Cardiology Section of EAPC (Pelliccia et al., 2019) were as follows: 35 mixed, 8 endurance and 6 skilled. Cardea and CON flagged 24% (12/49) and 39% (19/49), respectively, for clinician review. Except for QRS axis (in degrees) (r=0.31, P<0.05), there was a strong, positive correlation between Cardea and CON in measuring heart rate (r=0.93, P<0.0001), PR interval (r=0.84, P<0.0001), QRS duration (r=0.91, P<0.0001), uncorrected QT (r=0.94, P<0.0001), QTc (r=0.82, P<0.0001), P axis, (r=0.87, P<0.0001) and T axis (r=0.97, P<0.0001). Of note, the standard deviation of the differences in QRS axis measured by Cardea and CON was estimated to be 35 degrees. Bland-Altman plot revealed limited but varying levels of systematic biases in QRS duration, uncorrected QT, QTc, QRS axis and T axis.

CONCLUSION:

In this elite athlete population, there is good overall correlation and agreement in machine-reported basic ECG data between Cardea and CON, except QRS axis determination. The weak correlation in QRS axis between Cardea and CON may be of diagnostic importance (e.g. axis deviation) and potentially lead to over-/under-calls or inaccurate interpretation, warranting further investigation.

VELOCITY OF DESCENT UNDER THE BARBELL DURING THE SNATCH IN YOUNG ELITE ATHLETES: A PILOT STUDY

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INTRODUCTION:

Researchers and coaches identify the "Turnover under the barbell" as a critical phase for the Snatch exercise [1]. Increasing the barbell weight results in a decrease in vertical velocity and maximum height of the barbell [2]. Therefore, the athlete needs to descend faster under the barbell in order to efficiently complete the lift. Hadi et al. [2] calculated the negative velocity of the athletes during the turnover phase of the snatch, at different percentages of load using laboratory equipment, that is unpractical to be used during training. The aim of the present pilot study was to monitor the velocity of descent of the athlete under the barbell during a simulated competition in elite athletes.

METHODS:

Thirteen young elite male weightlifters (G1) of different weight categories of the Italian national team (age: 19,4 ± 2,63 yrs, bw: 72,46 ± 15,62 kg) were tested during a simulated competition organized by the coach to select athletes that would compete in the Mediterranean Games (Tarragona 2018). For our analysis we considered the best lift (1RM) and the previous correct lift (mean: 95 ± 0,58% of 1RM). A subgroup of 5 athletes (G2) was also tested during training at 80% of 1RM. We applied a visible marker on the coccyx of each athlete. A camera (Jeemak 4k, 120fps) was placed behind the competition platform. By analyzing the marker's trajectory (KINOVEA) we were able to calculate the athlete's velocity of descent during the turnover under the barbell. All data were tested for normal distribution using a Shapiro-Wilk test. Independent T-Test was used to compare velocity of G1. ANOVA one-way was used to compare velocity of G2. Pearson's correlation was conducted to assess the relationship between the increase in loads and the increase of athletes' velocity in G2.

RESULTS: