

(AMTI®), connected to the motion analysis system. Results The analysis yields for most of the parameters and curve conditions ICCs from good ( $r = 0.72$ ) to high ( $r = 0.96$ ) magnitude for the measured spatio-temporal and dynamic parameters. Conclusions Based on our findings it can be assumed that locomotion strategies, related to the measured gait parameters of common daily curve walking tasks, are stable and reproducible.

### COMPARISON OF KINETIC VARIABLES AND THEIR TIMING BETWEEN WALKING BAREFOOT AND WALKING IN TONING SHOES

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**Introduction** Previous studies have compared the kinetics of walking in toning shoes (TS) with walking in conventional shoes (CS) (Nigg et al., 2006; Stöggel et al., 2012; Taniguchi et al., 2012). However, the rationale for the development of the MBT shoe (a type of TS) was to mimic barefoot walking (<http://www.mbt.com>). Additionally, a limited number of studies focused on the timing of kinetic variables (Stöggel et al., 2010/2012; Taniguchi et al., 2012), whereas the timing of these variables is essential to accurately describe loading on the body during gait. Therefore, the goal of the current study was to compare the kinetics of TS with BF walking including the timing of the variables. **Methods** Three-dimensional ground reaction force (Bertec) and kinematic data (Flock of Birds) of the dominant leg were recorded for 13 college age females during gait at self-selected speed. Subjects performed three trials for the BF condition and three trials walking in TS (Sketchers Shape-Ups). Interpolation and filtering of kinematic and kinetic data as well as synchronization and time normalization of kinematic data with kinetic data were performed using Motion Monitor interface. Exported data were processed off-line using Matlab 7.6 software. Selected kinetic variables and their timing were studied to describe differences between the two conditions. Results Walking in TS showed greater impact peak and braking force in ground reaction force (GRF) than BF walking. This was accompanied by a more posterior center of pressure at heel strike and an earlier transition from deceleration to acceleration phase in TS condition. Shorter times were observed between the peak in ankle plantar flexion moment and the push-of-peak of vertical GRF, and acceleration force in anterior-posterior direction, respectively. **Discussion** Results suggest different strategies between the two conditions (BF vs. TS) to prepare for the swing phase. Furthermore, several of the observed characteristics of TS walking were similar to characteristics reported when walking in CS compared to BF walking. Further research will specifically focus on variability when comparing TS and BF. **References** Nigg BM, Emery C, Hiemstra LA (2006). *Med & Sci in Sports & Exer*, 38,1701–1708. Stöggel T, Haudum A, Birklbauer J, Murrer M, Müller E (2010). *Clin Biom*, 25, 816–822. Stöggel T, Müller E (2012). *Footwear Science*, 4, 131–143. Taniguchi M, Hiroshige T, Toru T, Ichihashi N (2012). *Gait and Posture*, 35, 567–572. Contact klousm@cofc.edu

### INDIVIDUAL GAIT PATTERNS ARE CHANGING MUCH MORE BY ITSELF

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**Introduction** Biomechanical diagnoses as well as therapeutic interventions typically assume quasi-constancy or nearly reproducibility in their subjects. Despite the knowledge of continuous changes in living systems, only a small amount of variation is tolerated without intervention. The aim of this study is to look for the reliability of force time curves of gait patterns over several hours. **Methods** Nine healthy and physically active subjects (three female, six male;  $27.4 \pm 3.0$  years) performed six sessions of 15 gait trials at a self-selected speed. The time intervals after the first, second and fifth session to the beginning of the subsequent session were ten minutes. The interval between session two and three and between session four and five were 30 and 90 minutes, respectively. For each trial the ground reaction force of one gait cycle was recorded by two force plates (Kistler, Switzerland) at a frequency of 1000 Hz. The estimation of changes over time based upon the classification rates of support vector machines, which were conducted for each subject individually by means of a multi-session- and session-on-session-classification. The Liblinear Toolbox 1.4 (Fan et al., 2008) was used with a leave-one-out cross-validation to distinguish the classification rates. Descriptive results were presented and statistically tested by a repeated measures ANOVA in four time intervals (T1: 10 min, T2: 30-50 min, T3: 90-110 min and T4: 130-150 min). **Results** The mean classification rate for the multi-session-classification is  $59.5 \pm 9.0\%$ . The mean classification rates for the session-on-session-classification result T1 ( $71.6 \pm 14.3\%$ ), T2 ( $85.8 \pm 14.7\%$ ), T3 ( $83.3 \pm 12.3\%$ ) and T4 ( $92.2 \pm 9.3\%$ ). The statistical test shows significant results over the four time intervals ( $p = .000$ ). The pairwise comparisons of T1 and T2 ( $p = .006$ ) as well as T1 and T4 ( $p = .001$ ) are significant, T1 and T3 ( $p = .085$ ) show a statistical trend, whereas T2, T3 and T4 show no statistical trend. **Discussion** The multi-session-classification rate of 59.5% clearly differs from a random classification of 16.7% and points out differences between the sessions. The session-on-session-classification trends that increasing classification rates go along with increasing time durations between the sessions. This shows differences of the gait patterns and thus indicates changes of the movement. Several reasons like structural system changes, adaptation to the experimental setup and the effects of pauses could cause these changes and should find consideration in further research. The results lead to rethink the classical relationship between diagnosis and therapy or training fundamentally. **References** Fan RE, Chang KW, Hsieh CJ, Wang XR, Lin CJ (2008). *Journal of Machine Learning Research*, 9, 1871–4. Contact horst@uni-mainz.de

### ANALYSIS OF IMMEDIATE EFFECTS OF UNEVEN GROUND ON GAIT PATTERNS BY MEANS OF SUPPORT VECTOR MACHINES

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**Introduction** The direction and amount of immediate and delayed effects of interventions are of most interest for training and therapy. The purpose of this study is the immediate (proprioceptive) effect of a mechanical stimulus by an uneven ground surface on the human gait. Effects of ground incline on the muscle activity in a gait study were shown by Klint et al. (2008). For the diagnosis of individual characteristics a complex pattern recognition approach has been suggested (Janssen et al., 2008). With a similar approach Tscherner et al. (2013) could show influences of shoe midsoles on gait patterns. In this context the holistic and immediate effects of an uneven ground surface on time continuous data of the normal human gait were analyzed by means of Support Vector Machines (SVM) and Root Mean Square Error (RMSE). **Methods** In this study 22 young adults completed ten gait trials before and ten gait trials immediately after an intervention of ten minutes. Kinematic data was captured with a marker based infrared camera system (Qualisys, Sweden) at 250 Hz. The joint angles of the lower body were calculated for the hip, knee and ankle. Kinetic data was measured as ground reaction force (GRF) with two force plates (Kistler, Switzerland) at 1000 Hz for one gait cycle. After post-processing both datasets were used separately for further analysis.

The intervention consisted of ten minutes barefoot walking on a path of 6 m length and 0.5 m width. The path was mounted with terasensa® foam panels with an uneven ground surface. Support Vector Machines were applied to classify conditions before and after the intervention intra-individually using the leave-one-trial-out method. RMSE was calculated over the continuous data of all trials of one condition for every participant and statistically tested for significance with the paired t-test. Results The mean classification rates were 68.4% ( $\pm 15.1\%$ ) for the kinetic and 83.4% ( $\pm 15.2\%$ ) for the kinematic dataset. No significant differences between the conditions could be found in the RMSE ( $p > 0.2$ ). Discussion The mean classification rates for the GRF data are relatively low and do not indicate a clear influence of the uneven ground surface. On the other hand the kinematic data results remarkable mean classification rates. Influence of the intervention on the individual gait variability could not be shown. In summary, although the results are ambiguous, they give an advice for an immediate effect of the uneven ground surface on human gait patterns. References Klint R, Nielsen JB, Cole J, Sinkjaer T, Grey MJ (2008). *J Physiol*, 586(Pt 19), 4643-8. Janssen D, Schöllhorn WJ, Lubienetzki J, Fölling K, Kokenge H, Davids K (2008). *J Nonverbal Behav*, 32(2), 79-92. von Tscherner V, Enders H, Maurer C (2013). *PLoS One*, 8(7). Contact eekhoff@uni-mainz.de

### 3D KINEMATIC ANALYSIS OF TWO DIFFERENT ROUNDHOUSE KICK IN ELITE KARATE PLAYERS

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Introduction The main objective of this study was to determine differences, if any, in three-dimensional (3D) kinematic characteristics of the two kind of roundhouse kick (Giako and kizami mawashi geri), elite level karate players. Specifically, the kinematic variables related to the displacement, linear velocity and acceleration of the lower body segments, translational leg acceleration and vertical ground reaction force generated by karate players were analyzed. Methods The subject of this study composed of 21 elite level amateur male karate players. Ages of the subjects ranged from 20 to 26 years old. All subjects executed two kick. The motions were captured with Phases pace real time optical tracking system with 8 high speed cameras at 240 fps. Then, the motions captured were analyzed to quantify the kinematic factors associated with each kick. Results The results showed that the kizami mawashi geri generated larger linear velocity compared to the giako mawashi geri. Similarly, the kizami mawashi geri generated larger linear acceleration compared to the giako mawashi geri. Moreover, the giako mawashi geri generated larger transitional leg acceleration compared to the kizami mawashi geri. Discussion As a conclusion, the results for all kinematic variables demonstrated that the type of kick was the major determinant of the magnitude of each factor studied. Moreover, the technique employed can significantly affect the resulting displacement, linear velocity and acceleration, and transitional leg acceleration of the kick. References Mori S, Ohtani Y, Imanaka K. Reaction Times and Anticipatory Skills of Karate Athletes Tokyo. *Human Movement Science*. 2002;213,18. www.WKF.com. 2013. Link N, Chou L. *The Anatomy of Martial Arts* Berkeley: USA; 2011; 48-53.

### A KINEMATIC ANALYSIS OF THE DOUBLE-SIDE KICK IN POINT-FIGHTING

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INTRODUCTION Point-fighting is a kickboxing discipline, which is characterized by a scoring-system, in which only the first regular strike scores. After a short break, the fight is then continued from the starting positions. This affects the tactics and techniques generally used. The basic movements comprise offensive and defensive foot- and hand techniques to attack head and body of the opponent. The aim of the study was to analyse the offensive combat kicking technique 'double-sidekick' which seems to be the basic movement for all offensive kicking techniques in pointfighting. This technique comprises two kicks with distance reduction to the target whereby the second kick reaches. In high level fights, realizations of this technique have been observed, which differ from those predominately taught. Top class fighters seem to raise up their kicking knees very high and accomplish to straighten up their upper body simultaneously. METHODS 44 fighters from 7 countries participated in the study. 8 won at least one world championship, 8 at least one European championship, 25 at least one national championship and 20 at least one high ranked international tournament; 15 participants were at advanced level without any noteworthy success at competitions. The athletes performed double-sidekicks to chest level with the aim to score, like in competitions. A Vicon 3D-motion capturing system comprising 8 cameras was used for kinematic data acquisition. The fastest one (of at least 3 kicks) was taken for further analysis. Knee height of the kicking leg (KHK) and distance between knee and shoulder (DKS) at two measuring points (MP1 and MP2) defined by the highest elevation of the knee before the first and the second kick were determined and normalized by anthropometric measurements. 10 experts with long-term experience in coaching of international top athletes scored the competition techniques (1-10) by assessing their chances of success based on videos of the individual executions (ICC: 0.952). By this, the fighters got categorized in 5 groups. The Spearman test was used to analyse the correlation between normalized DKS, KHK at MP1 and MP2 and the experts' categories. RESULTS AND DISCUSSION Normalized KHK is larger and DHS smaller for better categorized athletes at MP1 and MP2 (KHK:  $r=0.677/0.402$ , DKS:  $r=-0.664/-0.487$ ;  $p<0.01$  for all tests). The kicking technique of successful point-fighters is characterized by a high elevation of the kicking knee and a concurrent erected body position before and between the two kicks (at MP1 and MP2). Practical implications for physical training are to improve the strength of the hip flexor, the abductor and the lateral abdominal muscles and to stretch the adductor and ischiocrural muscles.

### EFFECTIVENESS OF MUSCULAR STRENGTH DRILLS IN ACHIEVING BALANCE OF ARM AND SHOULDER MUSCLES AND THEIR EFFECT ON KINEMATIC VARIABLES OF STRAIGHT PUNCHES

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During any boxing match, muscular Strength is one of the most important physical components needed by the boxer to perform various offensive and defensive skills and improve the speed and effectiveness of his or her punches. The aim of this study was to study the effectiveness of muscular strength drills on achieving balance of arm and shoulder muscles and their effect on the kinematic variables of straight punches for Boxers. To do so, an experimental study with a one-group pretest-post test design was conducted. The study participants were ten boxers aged 17-18 years from Mansoura Sports Stadium. The participants completed 6 alternating units of weightlifting and special power training sessions per week for 12 weeks. Pretests and posttests measured the balance in muscle strength via 1 RM, the muscular ability of arm and shoulder muscles, and the strength endurance of the boxers. In addition, two 250-fps SportsCams were used for 3-D Motion Analysis and Simi Motion software was used for kinematographic analysis. Comparison of the pre- and posttest results suggest that the participants did benefit from the experimental program. Average muscle strength increased by 25.82% for flexors