New media supported, child-oriented Pilates as intervention to stabilize posture and to correct postural defects on pupils aged 10 – 12

D. Deutschmann[1], M. Parfant[2], H. Holzer[3], M. Ebner[4], G. Ivanic[5], M. Svehlik[6], A. Weiglein[7]

[1]Medical University Graz, Austria. [1]dietlind.deutschmann@stud.medunigraz.at

[2]Graz University of Technology, Austria. [2]m.parfant@student.tugraz.at

[3]Institute of Sports Science, KF University Graz, Austria. [3]hans-peter.holzer@uni-graz.at

[4]Institute for Information Systems and Computer Media, Graz University of Technology, Austria. [4]martin.ebner@tugraz.at

[5]Department of Orthopedics, Privatklinik Graz Ragnitz, Austria. [5]gerd.ivanic@ok-institut.at

[6]Department of Pediatric Surgery, Medical University Graz. [6]martin.svehlik@medunigraz.at

[7]Institute of Anatomy, Medical University Graz, Austria. [7]andreas.weiglein@medunigraz.at

Introduction

Nowadays back pain due to postural defects is one of the most frequent chronic symptoms in our population. Particularly the number of school children with postural defects is increasing [1]. The earlier a weakness in posture, influenced by muscular imbalance for example, is recognized the higher the chances to prevent further defects [2]. The aim of this study is to show the effect of a regular short Pilates-program to stabilize posture in school children. New digital media is supposed to support motivation of the subjects and to help evaluating their activity.

Methods

For this study 128 pupils (46 males and 82 females) at an average age of 10,77 (SD 0,30) years were recruited. The study has been conducted in two secondary schools in Graz and nearby Graz. Posture was tested by the spine analysis program Zebris CMS-System [3] and muscle function was measured using the tests of Janda [4].In addition, a questionnaire on physical activity based on the MOMO-questionnaire [5] was implemented. Subjects were divided into intervention (n=77) and control groups (n=51) (see Table 1).

	Intervention group (n=77)	**Control group** (n=51)
age [years]	**10,77** ± 0,32	**10,78** ± 0,27
sex (m/f)	**37** (48%) / **40** (52%)	**9** (18%) / **42** (82%)
residence (urban/rural)	**27** (35%) / **49** (63%)	**12** (24%) / **39** (76%)
height [cm]	**147,00** ± 7,67	**145,69** ± 6,98
weight [kg]	**37,53** ± 7,08	**37,90** ± 7,05
percentile [%]	**45,86** ± 30,48	**51,05** ± 27,81
sports activities (frequency/week)	**4,72** ± 1,41	**4,24** ± 1,51

Table 1: Demographic data of intervention and control group at the beginning of the study

The intervention took place in sports lessons at school over a total period of one year and two months. Children in intervention group should also perform the sports program – ten exercises with ten repetitions in ten minutes with the help of the little magician “*Wirakulix*” – at home every day but at least three times a week. Subjects in control group did not get any intervention, they just participated at the regular sports lessons in school.

For monitoring and supporting this task, an iPhone-application, which is called *MotionTracker*, was especially implemented for this study (Apple AppStore [6]). All participants had to register their movements by the help of a diary, an online-diary or the iPhone- app. 17 out of 77 kids (22,1 %) had the appropriate advice to use the app.

iPhones are shipped with an accelerometer and a gyroscope. Both sensors supply data for the three-dimensional space with a sampling rate of 50 hertz. Figure 1 shows the rotation rate over the time, which is delivered from the gyroscope sensor in the iPhone, of the exercise “Spine-Twist”. The red curve corresponds to the rotation rate in the z-axis, which has a significant amplitude in this movement. On the other hand, the rotation rates of the green x-axis and the blue y-axis are relatively small.

The provided data was used for classification. A typical classifier consists of five components - collection, segmentation, feature extraction, classification and post processing [7]. The segmentation was done with peak detection on the gyroscope data. Each exercise had a significant shaping which was utilized. Using these extracted gained data sets, a data matrix which consisted out of six columns was built. These columns were the three-dimensional rotation and acceleration data and the count of rows depended on the time interval. From this resulting matrix different features were extracted for classification with support vector machines. Li, Kulkarni and Prabhakaran suggest to use singular values for classifying motion patterns [8]. These singular values as well as classical features like the mean (expected value) and the standard deviation from each of the different dimensions, cross-correlations between them and between the whole three-dimensional acceleration and rotation data, were used.

The different categories were interpreted as exercises in this context. Support vector machines divide two categories with a so called hyperplane that maximizes the distance between them. To calculate this optimal hyperplane training data is needed, the calculation and optimization is called training of the classifier. This training data was produced using different kids as test subjects. They had to perform the different exercises and also the different typical errors. For this purpose thirty kids performed a total of 451 repetitions of the different exercises, which means that each exercise had an average of about 75 positive training samples. Training samples of different exercises as well as simulated samples served as negative training samples. The relation of positive to negative samples and subcategories (e.g. typical error, well done) to each other was about 1 to 1.

For each exercise a fixed reference point was defined, which is fundamental for its movement and to classify the gained data from the sensors of the iPhone. Before the kids started with their workout, they had to attach the device to this reference point (see Figure 2). When they had finished the sports program, which was signalized by a simple touch of a button, they got the evaluation of the recorded movements. *MotionTracker* counts repetitions, provides feedback about the accuracy and suggestions for improvement of the accomplished

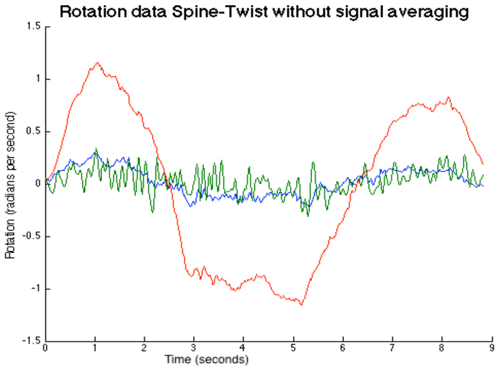

Figure 1: Rotation data, delivered from the gyroscope sensor of the iPhone, of the exercise “Spine-Twist”

Figure 2: A kid with an attached device during workout

exercises.

The whole workout is stored on a server and evaluations of the workout history can be found by the kids and also the therapist via a simple web application. Furthermore, the therapist gets additional information about the rate of participation and precision of the movements.

Finally after more than one year of intervention all tests from the beginning of the study were repeated.

Results & Discussion

Basically, the app enables a possibility to perform exercises at home in a controlled situation. Although this approach provides good results, it is somehow limited, as it can only monitor one fundamental part of the movement. Because of that, not all of the movements can be monitored, i.e. legs cannot be monitored when the reference point is on one of the arms.

The implemented *MotionTracker*-system was also evaluated with four children, all with different prerequisites concerning the age and the physical level. They were told to accomplish ten repetitions of all six exercises of the workout, which could be registered with the phone. Practically this was not always possible because the children performed test repetitions, counted wrong or were not able to finish it because the fitness level was too low.

Altogether there were found 633 possible repetitions of the different exercises, 223 were real repetitions and 410 randomly found segments. The implemented system could recognize 189 of the 223 real repetitions, which resulted in a hit rate of about 84.75 percent. 73 of the 410 randomly found segments were falsely assigned to real repetitions; this corresponded to a fallout rate of about 17.8 percent. Totally the correct classification rate is about 83.1 percent.

The result showed that nearly all real repetitions could be found. Relations between the complexity of the exercises, the amount of movement in it and the hit rate were noticed. More complex exercises achieved the lowest hit rates. For all others a practically sufficient hit rate of more than 95 percent could be achieved.

The next essential step is to improve the rate of participation through gamification. This means motivational elements must be added to increase the fun factor for the kids.

The analysis of the intervention is still going on but first results show that in intervention (IG) as well as in control group (CG) muscle stretching decreased (IG: p=0,002; CG: p=0,001) and muscle strength increased (IG: p=0,001; CG: p=0,021) significantly. In observation of the intervention group separated in subjects who did fulfil the exercise recommendations (26,8 %) and in those who did not (73,2 %), it is recognizable, that subjects who practised less than three times a week had a significant decreasing in muscle stretching (p=0,042) and no significant change in muscle strength. At the other hand subjects who fulfil recommendations did not significantly change in muscle stretching but increased their muscle strength significantly (p=0,014). It is recognizable that posture of the intervention group was better at the end of the study. However, not all of the results concerning the effect of the sports program on the parameters of posture have been analysed yet.

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Ethical Statement

The study was approved by the ethical committee of the Medical University Graz, Austria (15.02.2013, EK-Number: 25-130 ex 12/13)