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COMPARATIVE STUDY OF MUSCLE FATIGUE IN TABLE TENNIS TRAINING - AN OUTLINE

Abstract

Table tennis is characterized with intermittent intervals of explosive (anaerobic) muscle activity, being the cause for use of interval training as the most suitable training method. Performance in the game is a function of the state of the neuromuscular system, i.e. its condition of (non)fatigue. A study has been conceptualized where top young players are monitored through kinematic, kinetic and surface EMG variables when performing a repetitive maximal forehand top-spin movement, practicing with a table tennis robot, in such a dynamics and duration as to induce fatigue. Sequences of 12 shots are followed by 10 second rest periods, and this is to be repeated during an overall time of 20 intervals. M. deltoideus anterior, m. deltoideus medialis, m. biceps brachii and m. pectoralis major are to be monitored, unilaterally. Kinematics of the upper body is to be measured using an ELITE system (Zagreb) or a VICON system (Vienna) respectively, ground reaction forces (GRF) using force plates (Kistler). Changes in time patterning of EMG signal waveforms are expected, while the decrease of the median frequency of the surface EMG power spectrum is to be used as a criterion of local muscle fatigue. Modifications of both, neuro-muscular and kinematic / kinetic patterns, together with decrease of performance are expected to appear with fatigue.

Key words: *table tennis, muscle fatigue, EMG power spectrum, 3D kinematics, GRF*

Introduction

Evaluation of the individual table tennis player in terms of physical preparation provides important information about his strengths and weaknesses. Testing is important for the player and for the coach to the conditioning programme because it allows determination of the entry level of fitness, comparisons to other players and provides information regarding the current fitness level. When developing table tennis-specific tests, it is essential that the test protocol accurately reflects physiological and technical demands of table tennis. Even though table tennis is considered as anaerobic in nature, players still need to have a high level of aerobic abilities.

In table tennis performance diagnosis of the aerobic capacity, using standard bicycle ergometer, treadmill or field test, are common (Kondrič, 2002). These procedures have the advantage in delivering a large number of qualitative and comparative data. But there are also disadvantages because the tests are not specific for racket sports. Changes between load and recovery in table tennis and also in other racket sports are mostly overlooked in such test procedures (Baum et all, 1996; Ellwood, 1992). Therefore, we think that it is necessary to develop tests that are specific to the demands of table tennis. Without proper time for recovery fatigue, overtraining and injury could result. The player's body needs time for rest and repair, both within an exercise session and between sessions (Chandler, 1998). In order to find out the amount of recovery time, we have first to determine the intensity of the exercise. Intensity depends also from the structure of the tissue that is stressed.

The purpose of this paper was to establish a standardised protocol of surface myoelectric (ME) signal measurement and analysis with the aim to evaluate muscle fatigue during cyclic dynamic contractions of M. deltoideus anterior, m. deltoideus medialis, m. biceps brachii, m. pectoralis major and m. quadriceps executing top spin strokes in table tennis. The criteria for the test design were that it should be performed in match-play situation and composed so that the test would be practical to use in the training situation.

Method

System Setup

The test system for table tennis consists of a table, a ball machine, balls, a force plate (Kistler), a kinematic system (ELITE / VICON), two video cameras usual in trade, a surface EMG system (DelSys) and a heart rate monitor (POLAR S610/S725X). All table tennis devices have to be ITTF approved. Fig.1 presents the measurement devices – without cameras for kinematic measurements. They are included into the ELITE system or the VICON system and, depending on the number of available cameras (a minimum number of 8 is recommended), are placed in a manner that markers can be detected as accurately as possible.

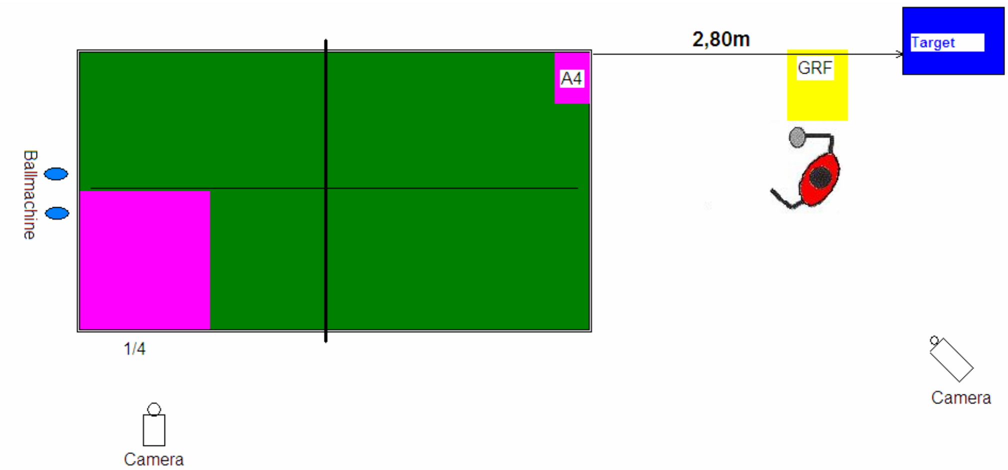

Fig. 1 Schematic drawing of the system setup

In order to put a reliable and objective spin on the ball, it is recommended to place and adjust the machine as follows: the ball hits the table at x = 21cm and y = 30cm (A4 paper), the second impact hits on the floor at x = 280cm (double A4 paper: 42 x 60cm). The ball frequency should be 60 balls per minute. The two Digital Video Cameras should be placed one beside the table (as high as possible, at least 2 m) to detect impact positions, the other one to monitor the player. Three-dimensional ground reaction forces F_x, F_y and F_z should be acquired at a sampling rate of 1kHz, using the force plate located 2m distant from the table. Heart rate has to be monitored during the whole session.

Test procedure

The subject has to perform top spin strokes from the FH corner (right handed) using the own bat / rubber. After warm up the player executes 12 topspin strokes, standing with the right foot on the force plate. The first two strokes are test strokes for familiarisation, the following 10 have to be analysed. After having executed all strokes, there is 1 minute rest. Afterwards, the same procedure is repeated. Next, the procedure for fatigued condition is started (12 top spin strokes, 10 seconds rest – 20 series, see Fig. 2). Data gathered from the two series with 1 minute rest and from the first series of the fatiguing protocol are used for analysing the non fatigued condition. The last three serie are assigned to the fatigued condition (above all, the time dependence of the fatiguing protocol is supposed to be interesting).

The balls are projected from a ball machine into the right corner of the table. The player has to stand on the force plate. The player has to hit the target on the opposite side of the table (1/4 of the table) with maximal ball velocity. If he/she is not successful in 30% of his/her strokes (manually observed) than the player has to finish the test.

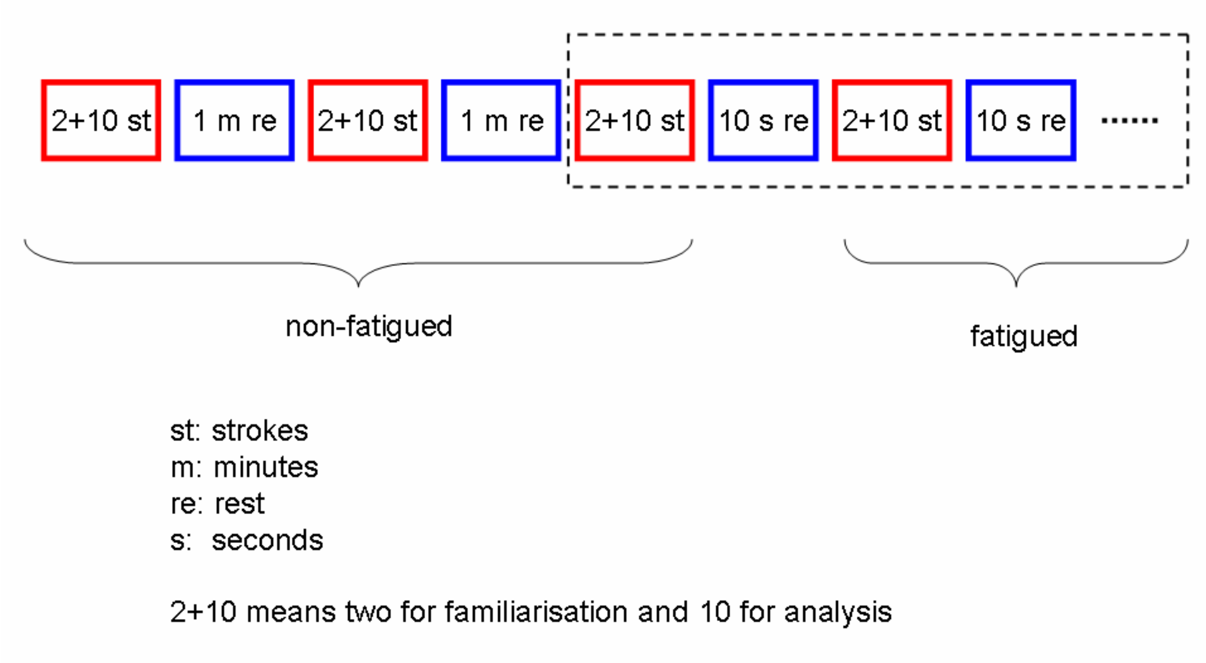

Fig. 2: Fatigue protocol

According to the SENIAM protocol (Hermens et all. 2000), surface EMG signals from m. deltoideus anterior, m. deltoideus medialis, m. biceps brachii, m. pectoralis major and m. quadriceps femoris (optional) are acquired and analysed with respect to time-, amplitude- and frequency characteristics (onset, RMS, median frequency). Two experienced human observers detect the onset of muscle activity from the EMG recordings.

At least 8 250-Hz infrared cameras are used to capture the kinematic movement of the markers (Plug-in-Gait Marker Set: upper body or complete set plus bat with three pin markers). After selection of at least three regular trials at the beginning and the end of the protocol, trails have to be tracked and analysed (stroke lengths, movement velocities and accelerations, joint angles of the upper right part (right handed) of the body). After that, the following four variables have to be calculated to identify the kinematic characteristics of the movement:

- stroke length,
- peak velocity of the bat (calculated as the centre of the minor axis)
- vertical component of the upper extremity
- acceleration peaks and distances

Hypotheses

Changes in muscular activity. In particular, in m. deltoideus after fatiguing conditions - increase of the activity level of the medial part because of permanent contractions,.

Changes in kinematics: more vertical components in the upper extremity, motion is less harmonical (high acceleration peaks), shorter acceleration distances.

Changes in GRF: only upper body movement, less changes within the GRF of one stroke, no real "swing phase".

Because of the higher anaerobic load we expect higher heart rate. On the other hand with measuring heart beats we control loads during the experiment.

Discussion

The principles of the exercise programme design refer to adaptation, specificity, recovery, variety, individuality and progression and are important both to maximise performance and to modify injury risk (Chandler, 1995). Fatigue of the table tennis player depends on the number of strokes accomplished in one point. A very important factor is speed. The speed of the top spin stroke depends on the stroke frequency and the stroke length. Stroke frequency is a neural drive, causing the muscles to contract and relax as rapidly as possible. Speed is also a function of the stroke length (swing), which depends on the kinematic chain.

The movement that the player has to perform is similar to those used when he/she is actually playing in match (Kondrič, Furjan-Mandić, Medved 2006). Therefore, players that have a good level of endurance fitness specific to the demands of table tennis should be able to perform well on this test.

Players should perform top spin strokes starting from the ankle (kinematic chain) and not just from the arm. To explore, if the player has actually performed top spin strokes from the ankle, ground reaction forces are analysed. To check the player's efforts, we also have to check the heart rate (acquisition of heart rate).

We also recommend to measure (if possible) blood lactate concentration after performing the test.

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