THE SIGNIFICANCE OF TITIN FILAMENTS TO RESTING TENSION AND POSTURE

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Muscular balance is one of the most widely discussed topics in sport science over the past years. The publications show a significant discrepancy between the accuracy of the numerous published statements on the theory of muscular balance and the small number of empirical studies. In the present investigation the authors examined both the logical and the empirical extent of the theory of muscular balance. Examination of the plausibility and the stringency of the argument showed that the theory of muscular balance lacks a scientific basis. However the empirical section disclosed a number of correlations between muscle function and body posture. Within a ten week training period the students´ average pelvic tilt was lowered significantly by a suitable program. This could arise from an increase of titin filaments and thus an increase of resting tension of the muscles straighten the pelvis.

KEY WORDS: pelvic inclination, spine, lordosis, kyphosis, muscular function, training, titin

INTRODUCTION: The theory of muscular balance is one of the most widely discussed topics in sport science over the past years. It is believed that a shortening of muscles which tilt the pelvis lead to a weak posture and backache (see Fig. 1 and 2). There is a significant discrepancy between the accuracy of many statements on the theory of muscular balance that have been published and the small number of empirical studies in this field.
Furthermore it can be stated that in most of the empirical studies posture was examined by means of visual assessment or via the muscular function test according to JANDA. Neither of these methods comes up to the high standard demanded by empirical methods concerning validity, reliability and objectivity. Only two studies, up to the present time, have examined the correlation between muscular function (the maximal isometric force (MVC) of the back extensors and the abdominal muscles) and posture (the pelvic inclination and the shape of the spine) based on empirical methods (Asmussen & Heeboll-Nielson, 1959; Klausen, Jeppesen & Mogenson, 1978). Neither study elucidated indisputable results in a way that could have been predicted by the publications on muscular balance.
In the field of „muscular balance, posture and exercise“ only a small number of empirical studies have been presented so far. Consequently there is a high demand for empirically reliable data on this topic.

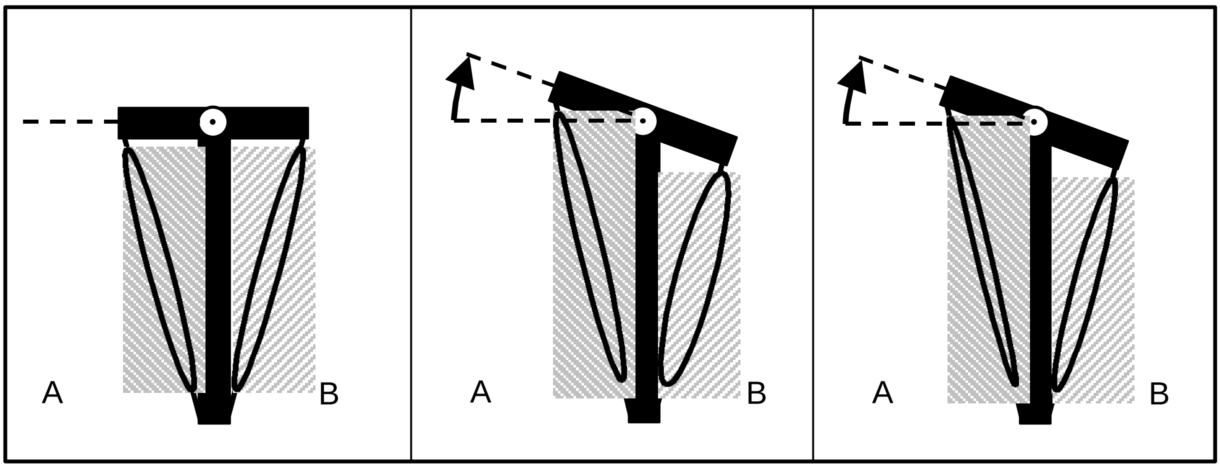


Figure 1:: Muscle balance as a result of an equal pull of the antagonistic muscles A and B | Muscle imbalance as a result of a short muscle B | Muscle imbalance as a result of a weak muscle A

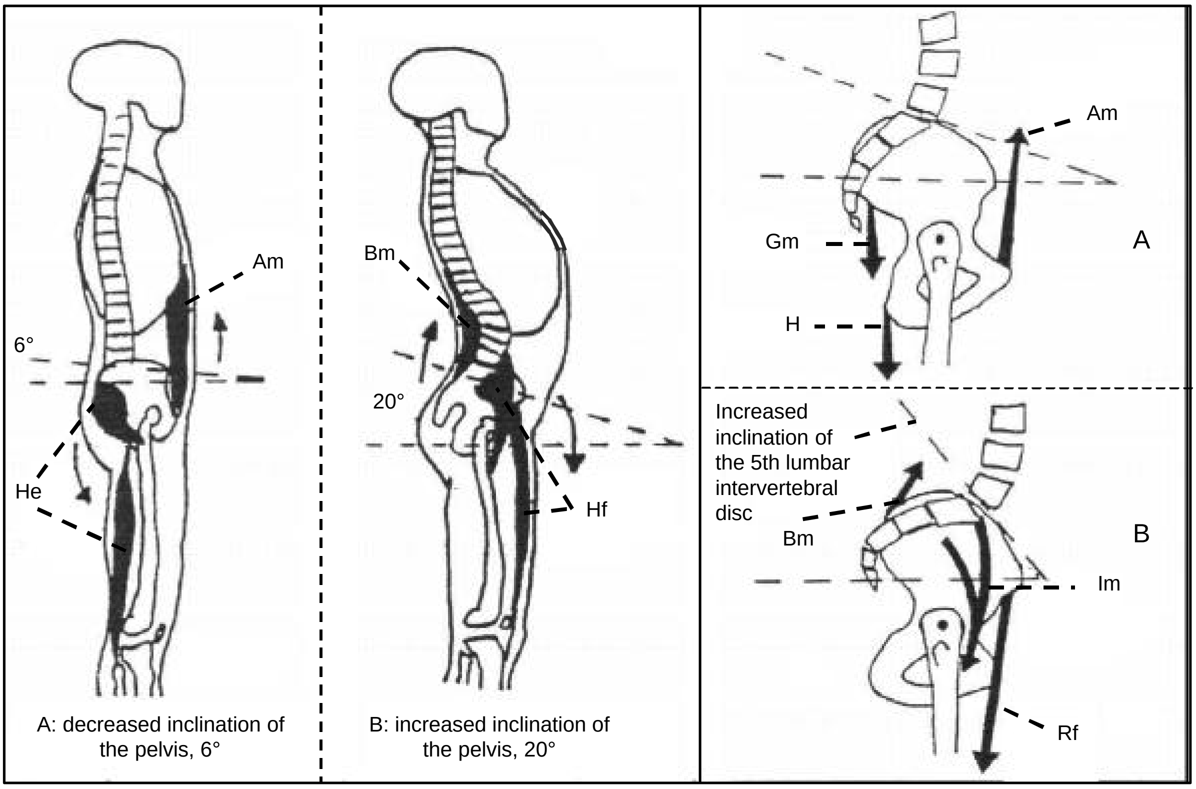


Figure 2: Muscles which influence the pelvic inclination. On the right below: Increased inclination of the 5th lumbar intervertebral disc as a result of an increased inclination of the pelvis. Am: Abdominal muscles, Bm: Low back muscles, Hf: Hip flexors, He: Hip extensors, Gm: Gluteus maximus, H: Hamstrings, Im: Iliopsoas muscle, Rf: Rectus femoris.

METHODS: In this study, 53 pupils volunteered as subjects. The following parameters were determined:

1. The posture and the "Armvorhaltetest" according to Matthiaß by taking and evaluating photos (see Fig. 3, 5).
2. The muscular function:
   a. The maximal isometric force (MVC) of the back extensors, the abdominal muscles, the hip flexors and the hip extensors (see Fig. 4, above);
   b. The range of motion (ROM), end ROM torque and resting tension of the hip flexors and the hamstrings (see Fig. 4, below),

Out of a total of 53 subjects, 40 of these volunteered to participate in a 10 week training experiment. They were divided into two groups of 20, according to their pelvic inclination whereas the remaining 13 pupils constituted the control group. Subjects with an above-average pelvic inclination took part in a training program designed to straighten the pelvis. The program included exercise to strengthen abdominal muscles and hip extensors. Stretching exercises for the back extensors and the hip flexors were also included. Pupils with an above-average pelvic inclination took part in a training program designed to achieve the opposite effect (anterior tilt of the pelvis) by means of strengthening of the hip flexors and the back extensors and stretching of the hamstrings.

RESULTS: While examination of plausibility and stringency showed that the theory of muscular balance lacks an empirical basis, the present study disclosed a number of correlations between the variables of muscular function, between pelvic inclination, lordosis and kyphosis, and between muscular function and posture. The correlations between pelvic inclination, the inclination of the lumbo-sacral section of the spine and between pelvic inclination and the lordosis are in line with the current theory of the muscular balance: As the pelvis becomes more straight, the lordosis becomes less marked. On average subjects with a more inclined pelvis show more distinct lordosis and kyphosis.

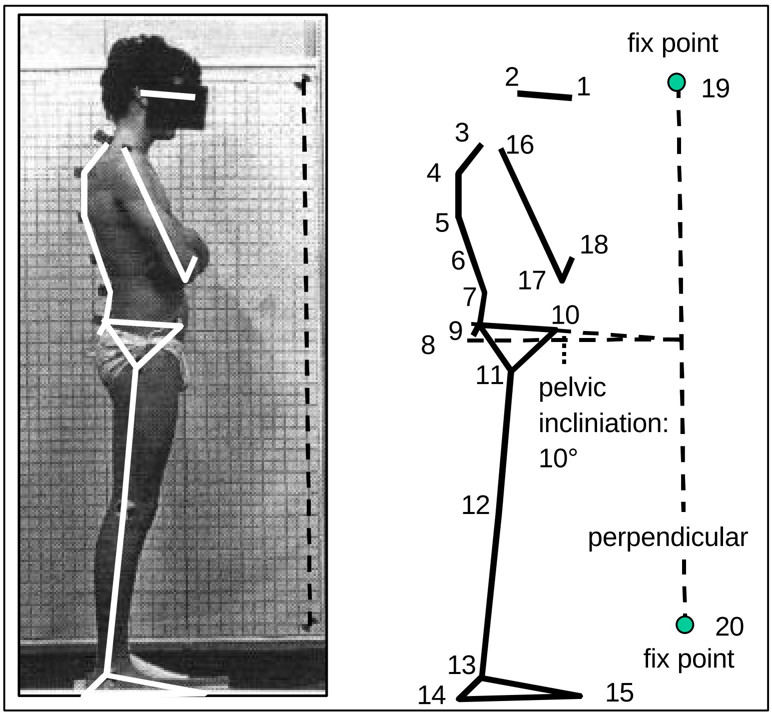


Figure 3: The photogrammetric measurement of the posture. Measuring points (Mp) 1-18:
1. Nose, 2. Ear,
3. vertebrae prominens, 4.-6. spine between Mp 3 and Mp 7,
7. max. lordosis, 8. sacrum,
9. spina iliaca post. sup., 10. spina iliaca ant. sup., 11. troch. major, 12. epicondylus lat., 13. malleolus lat., 14. heel, 15. 5th toe, 16. acromion 17. elbow, 18. wrist

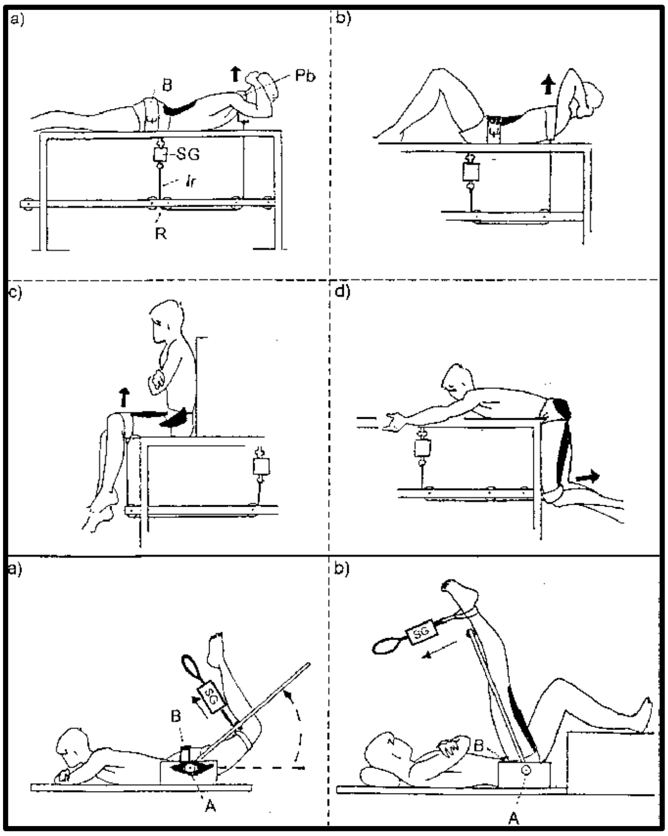


Figure 4: Above: Measurement of the maximal isometric force (MVC) of the back extensors (a), the abdominal muscles (b), the hip flexors (c) and the hip extensors (d). B: Fastening belt, SG: Strain gauge, Ir: iron rope, R: roll, Pb: pulling belt.
Below: Measurement of the flexibility (ROM, end ROM torque and resting tension) of the hip flexors (a) and the hamstrings (b). A: Axis of rotation with goniometer

Subjects with strongly developed abdominal muscles (in comparison with the hip flexors) show a smaller inclination of the sacrum i.e. a more straightened lumbo-sacral section of the spine. If subjects have strongly developed hip flexors in relation to their weight, they show a more inclined pelvis if they stand in a form of resting posture. The results of the present study showed an increase of ROM and end ROM torque of the hip flexors and the hamstrings within the respective groups. The resting tension in an angle below ROM was not effected. There was no decline of resting tension by the long-term stretching exercises.
The study demonstrated that, at the beginning of the "Armvorhaltetest" according to Matthiaß, tall, light people move their hip forward in a manner typical of persons with weak posture (Fig. 5). Apart from the previously mentioned results only a weak correlation exists between the "Armvorhaltetest" and the MVC of the abdominal muscles. Furthermore, the expected correlation between the "Armvorhaltetest" and the force of the back extensors could not be established. These findings suggest that the applicability of the

"Armvorhaltetest" as a method for diagnosis of posture faults in general, or to test the force of the back extensors in particular, has to be called into question. The central aim of the training program was to influence the degree of pelvic inclination. The results elucidated that the pelvic inclination was lowered significantly (2,16°, $p<0{,}01$) in the group participated in a training program to straighten the pelvis. This is in line with the hypothesis.

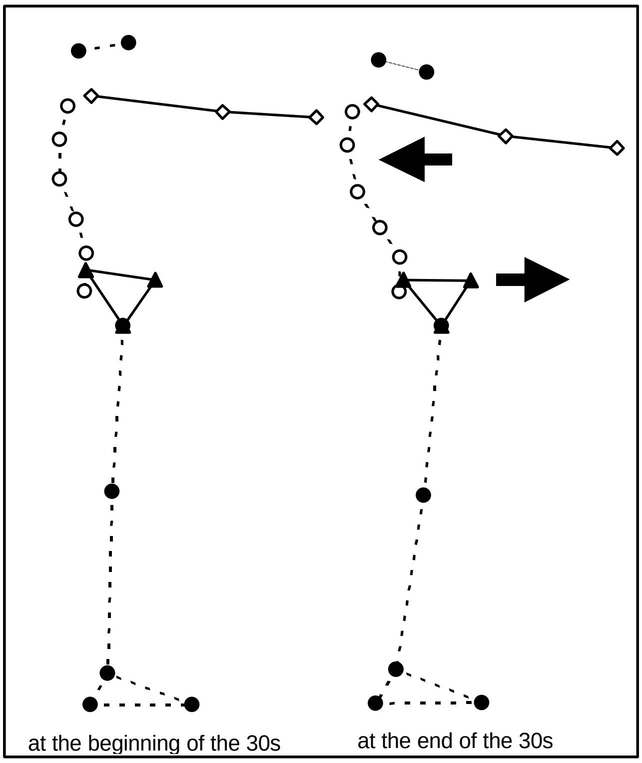


Figure 5: The "Armvorhaltetest" according to Matthiaß

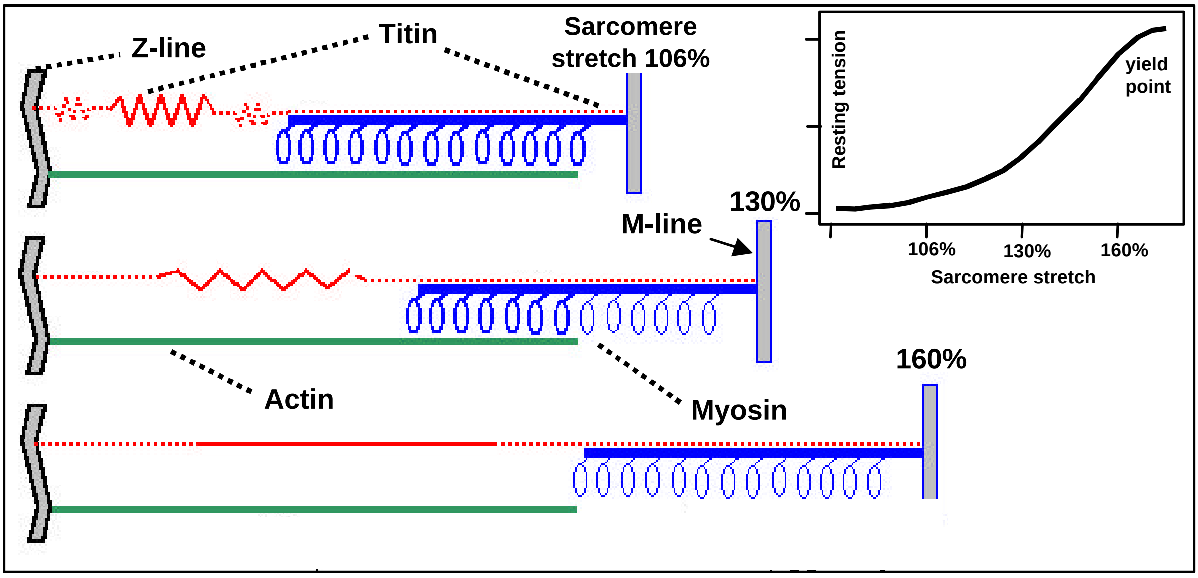
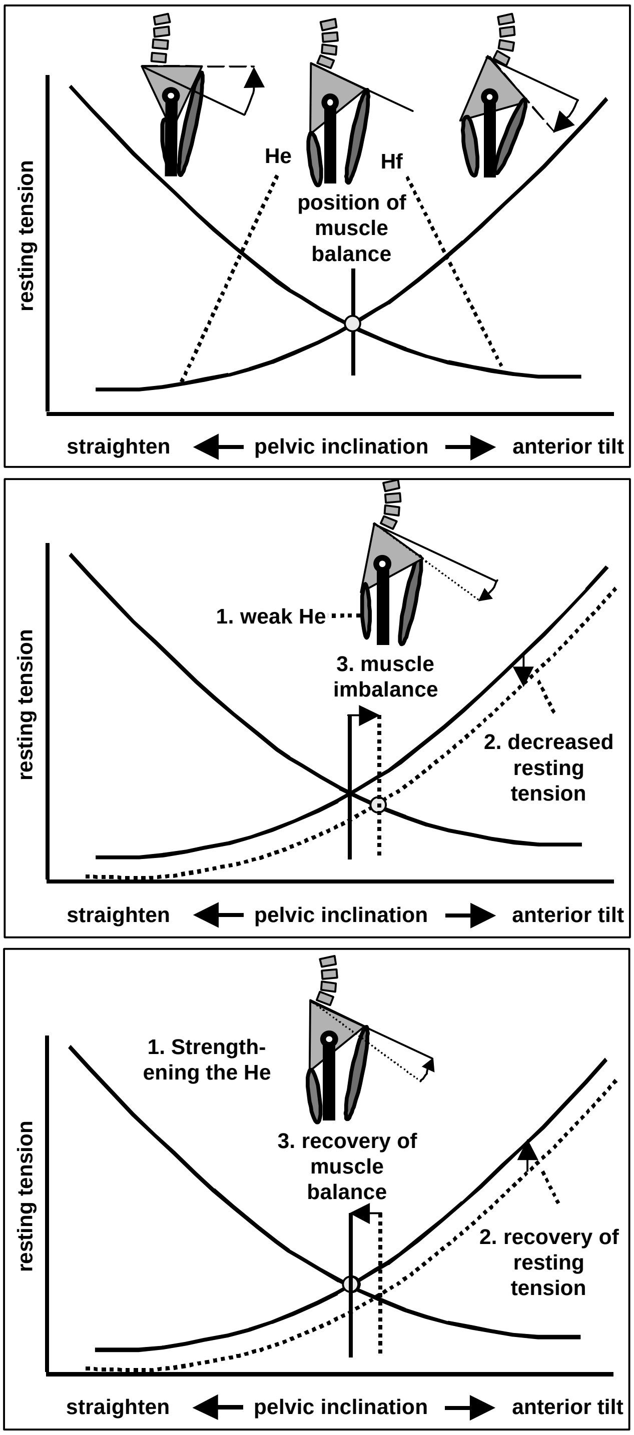


Figure 6: Model of titin extension with sarcomere stretch, <u>inset:</u> increase of resting tension

DISCUSSION: Many questions for further investigation remain open. Before considering possibilities to influence posture by means of training for example, it has to be clarified which kind of posture can be defined as being healthy. The accepted methods to legitimate a norm or standard posture i.e. calculating a mean value or evaluating according to theoretical - technical aspects can only be seen as a kind of guideline. The only way to legitimate standard values for factors which constitute posture is to prove a direct connection between the deviation of a defined standard value and backache. Until these questions have not been answered satisfactorily it can only be stated that an extremely inclined pelvis bears potential risk for health. The results of this study suggest that a muscular training brings about a



straightening of the pelvic inclination. We believe that the following factors are responsible for constancy of resting tension: Formerly, resting tension was attributed to elastic forces in the connective tissue and in the sarcolemma. Later on, it was demonstrated, that in intact muscles up to a stretching rate of 160%, resting tension arises from the elastic resistance of the myofibrils. Recently, the titin filaments have been identified as elastic molecular springs within the sarcomeres. They are responsible for the resting tension (Fig. 6). Restoring sarcomere length after stretching appears to be the most important function of titin. This physiological function may be the reason for the finding that resting tension of human hamstrings could not be lowered by stretching exercises (Wiemann & Hahn 1997). Since every single thick filament is associated with 6 titin filaments it can be suggested that hypertrophy leads to an increase of resting tension which brings about a change of posture (Fig. 7). Therefore, muscular balance should not be treated with stretching but with resistance exercises (Wiemann, Klee & Stratmann, 1998).

Figure 7: Correlation between resting tension of hip extensors (He) and hip flexors (Hf) and the degree of pelvic inclination

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