Flexi-Bar/Thera-Band Translation – pages 1 - 14

Flexi-Bar/Flexi-Band - translation by Ann Adler

The effect of a training programme on the level of strength and proprioceptive capabilities in the shoulder area

using oscillating apparatus

An investigation focussing on movements in volleyball

The following text is based on a thesis submitted in 2005 by Magdalena Kassenböhmer, a student of sports science at the Technical University in Munich

Introduction

Shoulder complaints in different types of sports are becoming increasingly common. For volleyball, in particular, the stress on the shoulder during the striking movement is especially high. Therefore it is not surprising that there are many volleyball players who suffer from shoulder complaints. There are a growing number of investigations into the causes and processes which will allow experst to draw the necessary conclusions for training purposes.

As the shoulder is a very unstable joint, one tries to stabilise it through the musculature (see Henne, 1997). Proprioceptive training is advisable, yet this is difficult to perform in the case of upper extremities. It is easier to carry out this type of training in the lower extremities, for example with exercises on a soft surface. This is equally true for testing the stabilising capability of the lower extremities. Consequently, there are well established methods in this field with which to test the effect of a proprioceptive training.

The mechanisms of the proprioceptive capabilities of the shoulder are comparable to those of the knee. (see Jerosch et al, 1996) Therefore training the capabilities of the shoulder must be based on the same principles which are applied to training of the lower extremities. As the oscillating training apparatus for the upper extremity follows this principle, it is to be assumed that training with this type of apparatus has an effect on the senses which can be likened to proprioceptive capabilities. The work outlined here is also based on the assumption that this type of apparatus has an effect on the parameters of strength, as has already been proven for the thera-band. (see Treiber, Lott, Duncan, Salven, Davis, 1998). For this investigation, a training device produced by the company *Flexi-Bar* was chosen which will be described as the flexi-bar. As training with the thera-band also makes relatively high demands on skills of co-ordination, the band is being used as a further

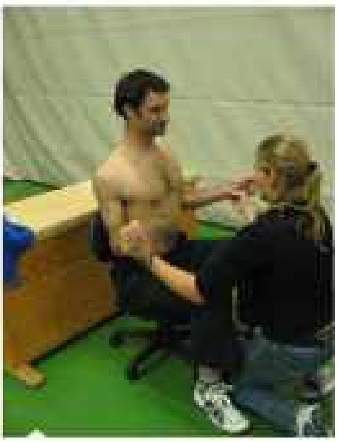
Flexi-Bar part 3

Description of the clinical investigation

In order to gain a thorough picture of the clinical state of the subject's shoulder, a physiotherapist carried out six manual tests. The physiotherapist completed the same procedure during the preliminary and follow-up tests.

The following tests were carried out:

- Infraspinatus/Teres minor test



- Lift-off test

- Jergason-test (long biceps tendon)

- Painful arc

- Stability test

- Apprehension test

Design of the questionnaire

The design of the questionnaire was based on that developed by Professor Immhoff (see appendix). The first part deals with antroprometic data, such as body size and weight, while the second part addresses training age, frequency of training, availability of a balance sport and other regularly practised sports. The questions are open-ended. The third section of the questionnaire deals with any form of pain and how this may influence the training, or whether they may be exacerbated by training. The questionnaire covers the subjective opinion on changes brought about in the shoulder area after training. The subjects choose from a range of pre-formulated answers, as this allows for easier evaluation. Results from the questionnaire are included in the test outcomes in order to check whether the objective results obtained through the measuring processes described above agree with the statements made by the subjects.

Evaluation of results

As mentioned earlier, the three tests were developed specifically for this investigation. It was important to find a way of analysing the data which had been generated in a rapid and meaningful way. The evaluation of the ball test and the pulley test was carried out with a Matlab 6.1 programmed script. For evaluating the punching mask test, Microsoft Excel 2003 was used. Following on from this, statistical analysis was completed applying the programme SP33 12.0. The data for the ball test, pulley test, punching mask and isokinet were calculated with the Wilcoxen test. Results with $p \leq 0.05$ were considered significant.

Evaluation of the ball test

The data for this revealed two parameters; on the one hand note was taken of the time required to regulate the deflection of the ball. On the other hand, the difference in angles between the starting and final position was recorded.

Data recorded were evaluated as follows: the maximum possible deflection of 32 °was set at 100%. The start of the deflection was set at 70%, i.e. 22.4°. The offset was calculated for the values in order to present them graphically.

The regularisation of the deflection is considered complete, once 500 of the current measurements are below the threshold of 20% at a scanning rate of 1000Hz. Within 0.5 seconds the sensor should not register any movement larger than 6.4 ° (equivalent to 20%) By analysing these data, it is possible to establish precisely how rapidly the subject reacts to an interference in the position. As the regularisation cannot take place to the value of one degree exactly, the threshold is set at 20%.

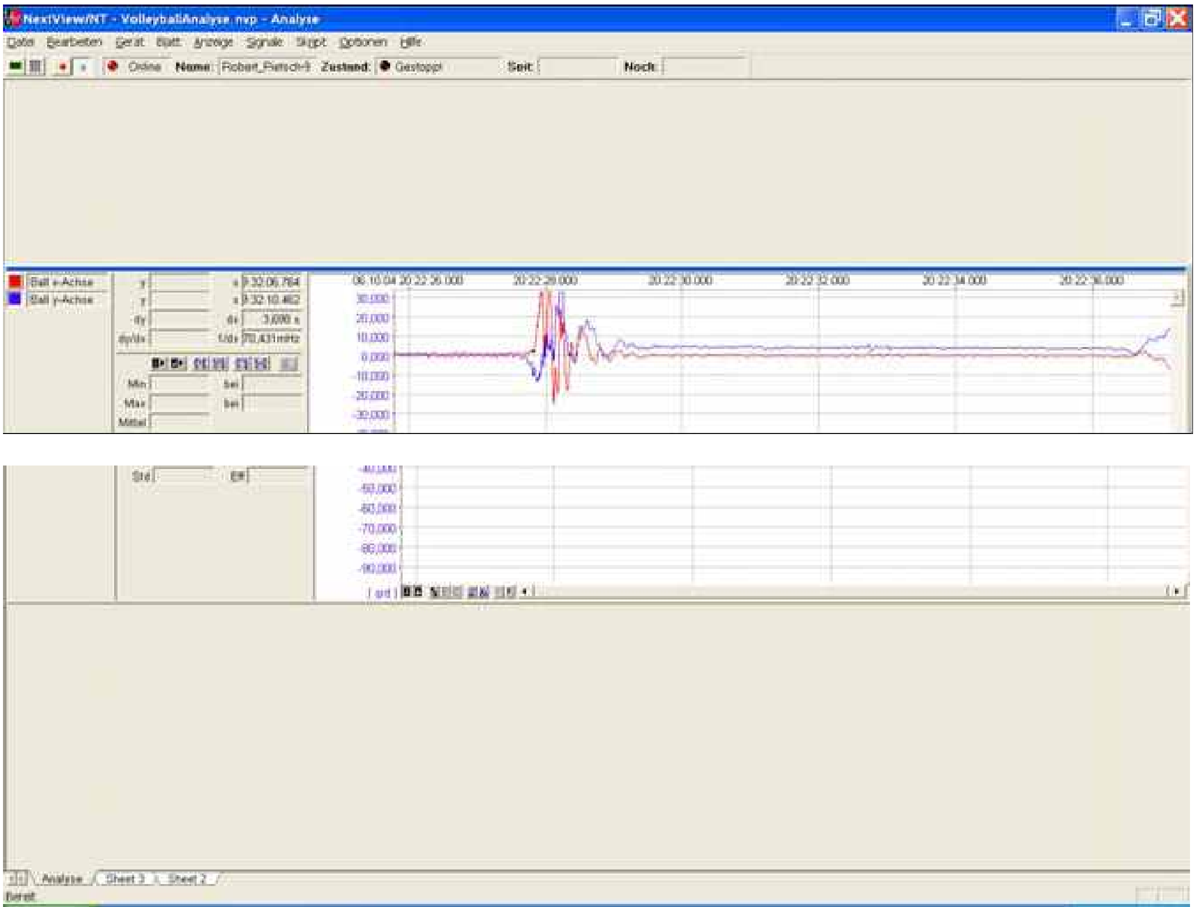


Figure 18: Screenshot balltest Next View

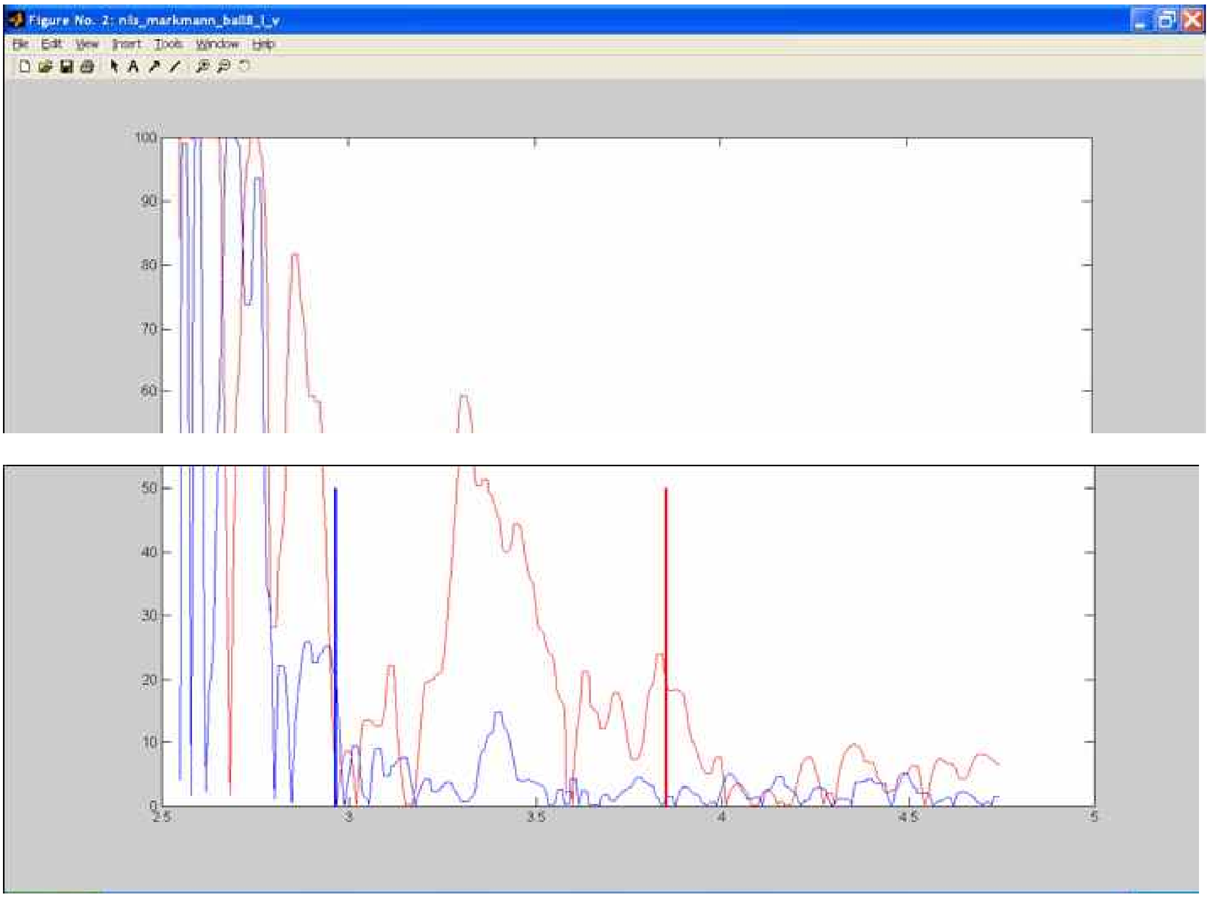


Figure 19: Screenshot evaluation of balltest, Matlab

By creating the offset, it is possible to reconstruct to what extent the end position of the subject differs from the initial position. These data needed to be further scrutinize in Excel in order to define the distance between the subject's position to the centre of the joint on the test apparatus. As this point does not move on one level, but along a semi-circle, the results in Excel were calculated with the formula $\phi d = \text{arc sin } \surd\sin^2\phi x + \sin \surd^2\phi y$. This angle provides information as to the subject's ability to find his or her original position after a disruption

Results of the ball test

In the case of the flexi-bar group the results of this test do not allow us to draw statistical inferences, as data from preliminary and follow-up tests are only available for five subjects. Therefore a descriptive method and analysis of single cases is used for following up the flexi-bar group.

Two of three groups showed improved results. The group which had trained with the thera-band showed a minor deterioration.   This is only at 2.6% and not to be regarded as significant ($p=0.594$).

The group which underwent normal preparation, time taken to regularize the deflection went down by 11.6%. Despite this improvement, the difference in results is not significant (p=0.173)

The results of the flexi-bar group, as represented graphically show an improvement of merely 5%. However, it is not really possible to compare these results with those of the other test groups, as only six subjects were tested initially and nine attended the follow-up test.

There are only five subjects for whom results of all three tests are available. At the initial test, these players took, on average 1.0103 seconds ± 0.236 to regularize the deflection, during the follow-up the results were, on average only 0.7159 seconds ± 0.246 at N=5. This would represent an improvement of 29.1%. With a total of 20 tests carried out on the dominant side of the five subjects, only one attempt on the dominant side showed a decline. The greatest improvement, after calculating an average result of the four tests for one person (dominant side), lies at 0.34 seconds for subject number 27.

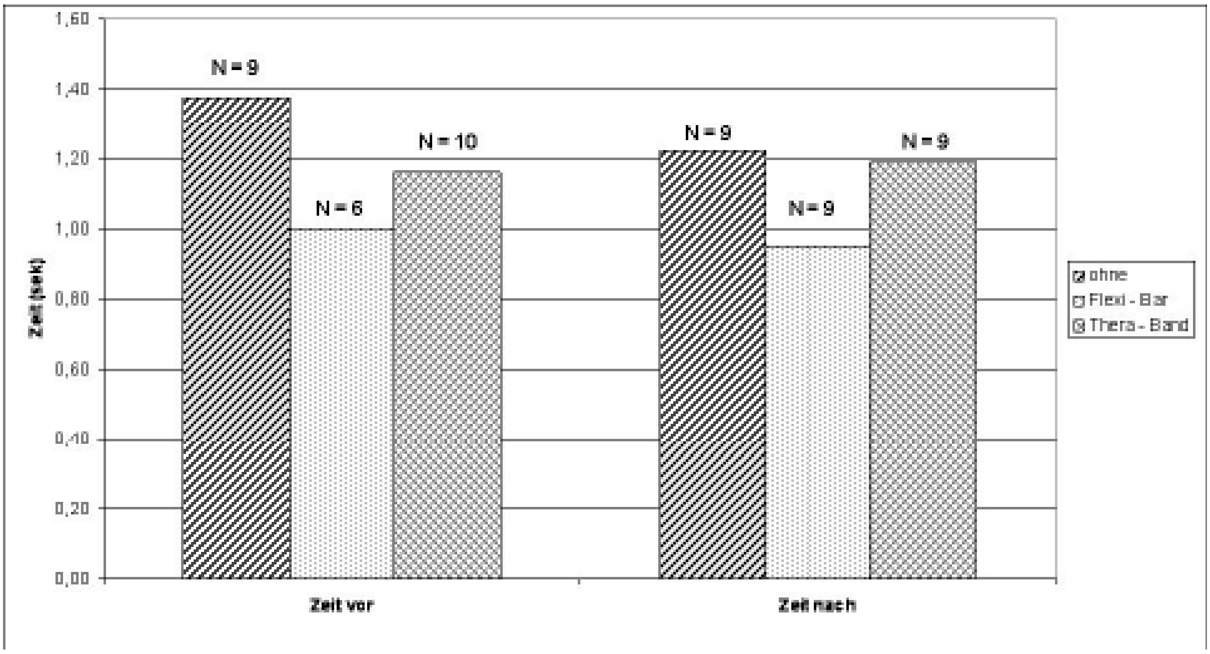


Figure 20: Average values for regulatory time, dominant side

Zeit = time

vor = before

nach = after

ohne = without

Insert graph no. 34 from original manuscript

Figure 21: Individual cases of regulatory time on dominant side

On the non-dominant side, results are similar to those on the dominant side. Improvements for the group which trained normally amount to 10.7%; again, this is not a significant difference (p=0.173). The thera-band group showed a deterioration of 27.4%, but this, too, cannot be considered significant (p=0.767).   For the flexi-bar group (with varying numbers of subjects) an improvement of 15.2% was noted.

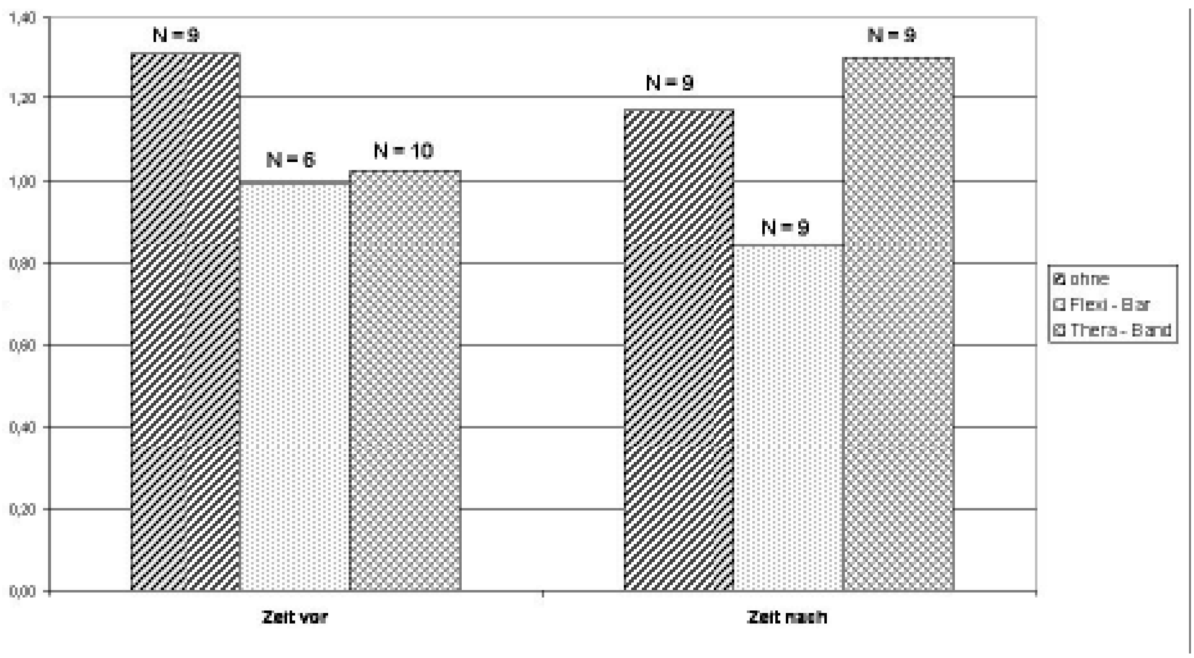


Figure 22: Average values for regulatory time,non-dominant side

Zeit = time

vor = before

nach = after

ohne = without

Looking at the five players, for whom all the results are available, an improvement of 23.6% is apparent.

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Figure 23: Regulatory time on non-dominant side

(end of page 70 in original manuscript)

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The subject carries out this test without having visual control over it. When the positioning has been checked, the spring is put under tension with the lever and deflected to the right or the left by a tester. On each side, the ball is moved twice in each direction, always beginning with the dominant side. The order in which deflection takes place is decided by the person supervising the test. The data are recorded using the Next View programme.

The test needs to be carried out by two persons, as one is required to operate the computer while the other operates the lever for deflection. To ensure that the subject cannot prepare for the moment at which the deflection takes place, it is essential that the two testers communicate the point at which the lever is moved by using hand signals.

Description and implementation of the pulley test

The pulley test is to establish, how well subjects are able to dose their strength during a sequence of movements.

In this test design, the subject stands with his back to the pulley. Feet are placed in a parallel position at hip width on the floor markings. The 150 cm high box allows the weight distribution to be the same for the preliminary and follow-up tests in that the subject lightly touches the box with the dorsal vertebrae.

The subject's weight should not be carried by the box. The wheels were set at the highest level as all subjects were tall and could consequently reach this height. The pulley used for this investigation has a six-fold transmission. The sensor, turning potentiometer, is mounted on the upper wheel, as this point marks the longest distance of rope. The potentiometer is operated at 5V and the data were recorded on the Next View programme.

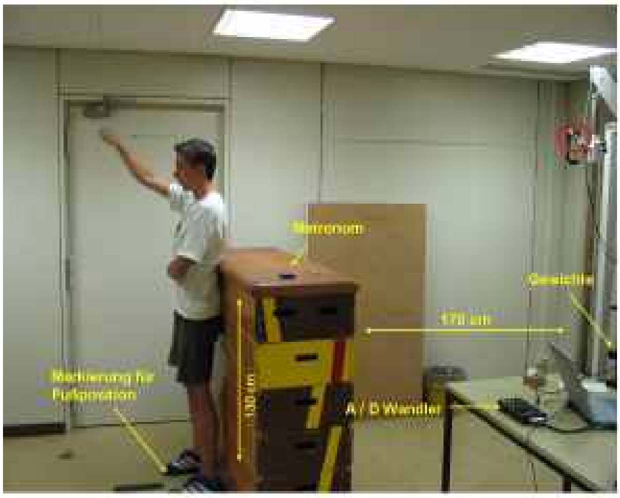


Figure 11: Set-up for pulley test

The weight, which is added in the course of the movement is attached to the basic weight with loops of 20cm length. The basic weight is 15kg, to which additional weights of 10kg or 15kg are added. This is implemented by placing the loops on the pole with the threading mechanism.

Figure 12: Mechanism with loops for adding weights

The movement begins at an elevation of 180° and ends at an elevation of 90°. This movement is to be carried out at a constant pace. A metronome, playing at 48 beats per minute, was used to ensure a regular pace. Once the subject is in the starting position, three trial runs are carried out so that he or she can keep the rhythm and the exact range of movement can be maintained. Once the subject moves to the rhythm of the metronome, a weight is added. Depending on the decision of the tester, this happens after a minimum of 5 and a maximum of 10 repetitions. The dominant arm is tested first. Before any weights are added, the tester must make sure that the subject maintains the rhythms throughout the experiment and completes the full range of movements. The experiment was carried out in an environment where the subject could concentrate fully on the rhythm and on moving as directed.

Figure 13: Starting and finishing positions during the experiment

Description and implementation of punching mask test

This test, designed specifically for this study, uses a punching mask to research the sense of position.

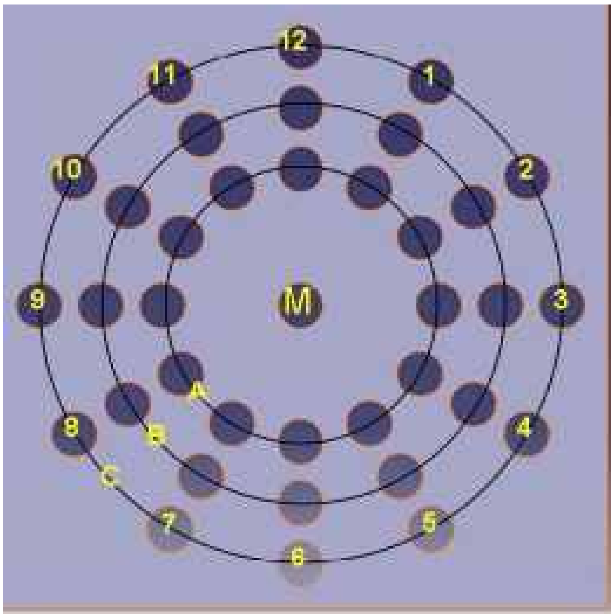


Figure 14: Diagram of the punching mask

The holes in the mask are arranged like the numbers on the dial of a watch. In order to achieve different levels of difficulty, three circles with different diameters were embossed on the material. The inner circle has a radius of 9cm, the middle one 13cm and the outer one 17 cm. The punching mask is mounted on a stand, the height of which is easily adjustable.

The subject's arm length is measured, in order to establish the angle in the shoulder joint for the individual positions.

The subject's shoulder axis is in perpendicular position to the punching mask. The mask is positioned in such a way as to allow the subject to touch the centre of the circles with a stretched arm at an angle of 90^o to the torso. When positioning the subject, it is important to ensure that the arm which is being tested is able to carry out a deflective movement. The subject needs to stand in a firm position throughout the duration of the experiment. In order to reconstruct the subject's position for follow-up tests, the height of the centre of the punching mask and the distance of the foot from the stand are noted. Prior to running the experiment, the subject is given a pair of glasses to avoid any visual control.

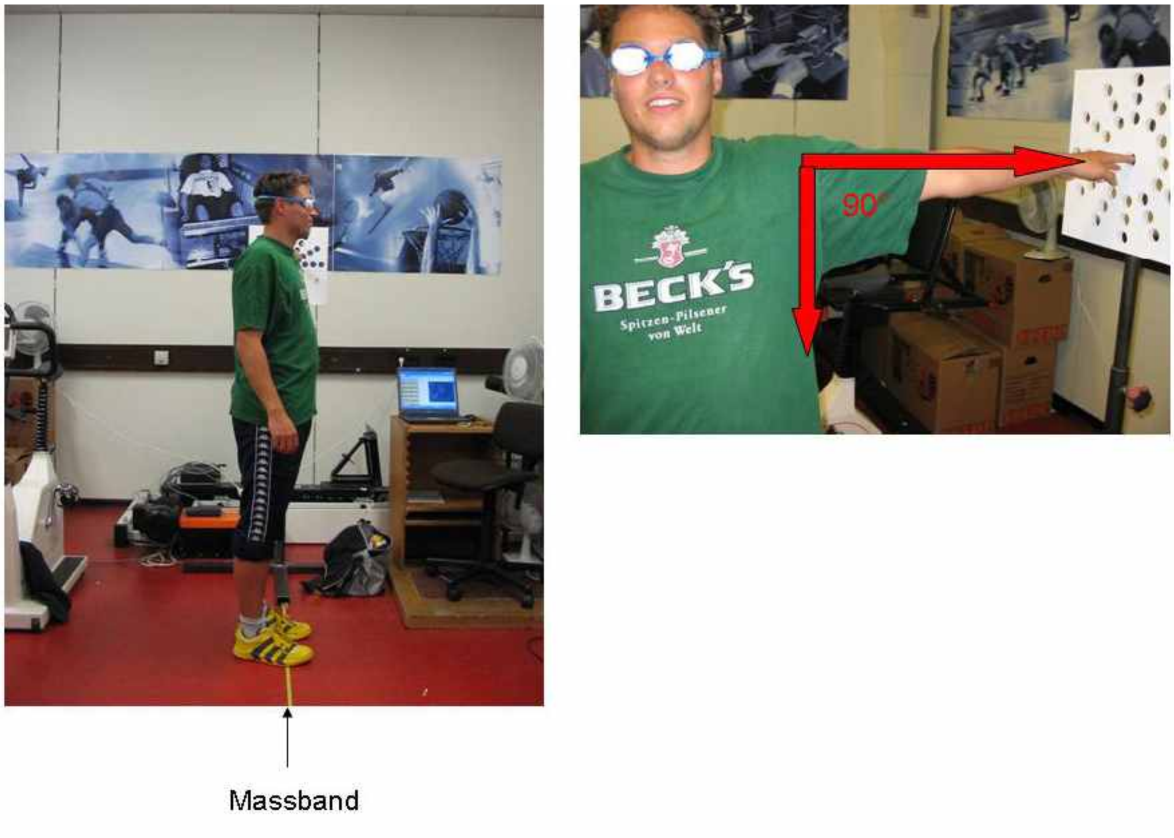


Figure 15: Starting position for punching mask experiment

Massband = measuring tape

The subject's arm is moved along the three concentric circles and he or she is told in where on the circle the pointer finger is to give some orientation help for the test to follow.

During the experiment, the subject's arm is moved and a finger placed on one of the holes. He or she must then describe the position of the hole as it would related to a clock face and describe on which of the three circles this lies. The tester must ensure that the subject is not asked to point to holes which are above or next to each other. The subject needs to maintain the starting position, especially the position of the shoulder axis to the mask. Five trials are run for each arm. Neither during nor after these is any information provided as to the accuracy of the subject's movements.

Description and implementation of the isokinetic test

The strength diagnosis was carried out with the training apparatus Cybex Norm. The data required for the parameters tested were recorded with the dynamometer. The different parameters, for example the torque or the average attainment can then be represented and documented.

Figure 16: Isokinet apparatus

As advised by the manufacturer, the test was carried out with a starting position of 90° deflection and the elbow flexed at 90°. The range of movement was limited to 50° internal rotation and 50° external rotation. (see (Wang, Macarlande, Cochrane, 2000). This range allows for optimal use of force.

The test was carried out at a speed of 60°/sec and 180°/sec, the speed being set and directed via the recording mechanism. The movement started with a 50° external rotation and the repetitions also ended in this position.

Figure 17: Range of movement on Isokinet

After getting into the correct position, the subjects were able to warm up at the apparatus (set at 120°/sec) and familiarize themselves with its characteristics. The test was run immediately after the warm-up. At 60°, five repetitions were run, at 180° /sec there were 20.

The test began at a speed 60°/sec. Internal and external rotations were measured within the same sequence of movement. After a break of 90 seconds, the test was continued at 180° /sec. The dominant side was tested first; before the non-dominant side was investigated, the apparatus needed to be rearranged. The test was always carried out by the same person comparative device, in addition to the control group. This approach allows us to establish whether the flexi-bar is preferable to the flexi-band in the field of co-ordination training.

Research to date

Research in the area of proprioceptive capabilities and co-ordination training concentrates primarily on the lower extremities. Few studies have been carried out on the effect of oscillating training apparatus on the upper extremity.

As in most current literature, the concept of proprioception or proprioceptive capability will be used throughout the following text.

Various investigations allow an insight into the neuro-physiological processes, which studies describe as proprioceptive capabilities. (see Gollhofer , Lohrer and Alt, 2000; Schmiek , 1985). Lepahrt et al (1997) and Sainsburg, Poinzer and Ghez, (1993) for example, study the role of proprioceptive capability in the stabilising of joints. These studies conclude that proprioceptive ability does, indeed, contribute considerably to the stabilising of the joints. With a view to practical application, Biedert and Meyer (1996) have considered which principles should be underlying to proprioceptive training in order for it to be effective. However, their more detailed studies are limited to the training of lower extremities.

Different studies consider the proprioceptive capabilities of the shoulder joint. In some investigations the focus is on the difference between stable and instable shoulder joints. The studies all employ different research methods, but are generally based on the principle of angle reproduction. Therefore, the studies reach similar conclusions, namely that the proprioceptive capabilities are lowered if the shoulder joint is instable. A further conclusion is that no difference can be found between the dominant and non-dominant side (see Aydin, Yildiz, Ozgürbüz, Yamur, Genc, Kalyon, 2000; Jerosch, Thorwesten, Steinbeck, Schröder, 1996; Lephart, Jon, Warner, Paul, Borsa, Fu, 1994). A further study (by Jerosch , Thorwesten and Teigelkötter , 1997) of young tennis players found that those who practise a type of sport which places demands on the tested structure exhibit improved proprioceptive qualities. The training age appears to be significant with children and teenagers, whereby capabilities are enhanced with higher training age.

On training apparatus with oscillation applied from outside, test results vary widely . Conclusions range from very effective to negative outcomes. These studies focus primarily on the effect of the training apparatus on different power components. (see Künnemeyer, Schmidtbleicher, 1997; Motta, Becker, 2001; Schlumberger, Salin, Schmidtbleicher, 2001). Haas, Turbanski, Kaiser and Schmidtbleicher (2004) attempt to explain the very disparate results. Their explanation for the irregular outcomes is that "... mechanical impulses are effective on multiple physiological levels..."

Another factor is that human reaction to the impulses does not happen in a linear mode. (see Haas et al, 2004).

There are very few studies on the effect of an oscillating training apparatus in which the oscillations are induced by the person in training. A study by Rieger, Heitkamp and Horstmann (2003) tests to what extent the musculature of the torso and shoulder girdle are activated by the training apparatus. Muscle activity has been derived with the help of an electromyogram. The result shows that it is entirely possible to carry out a ”focused and planned muscle training” with this apparatus.

Proprioceptive training programmes can be successfully carried out after operations on or weakness in the cruciate ligament; this was shown in studies by Rebel (2000); Jerosch, Pfaff, Thorwesten and Schoppe (1998) and Barrack, Skinner and Buckley (1989). In his study, Rebel develops a concept specific to particular phases for the training of proprioceptive capabilities. For the lower extremities, the literature quoted is only a small selection of research in this area, in which many further investigations can be found.

Pages 15 – 28 omitted

Strain experienced during striking movement in volleyball

As each type of sport makes specific demands on the muscular structures, it is important to consider these together with any strain which may be caused during training sessions and to draw the necessary conclusions when devising training programmes. Here the striking movement in particular will be considered and any resulting damage investigated.

There are four phases a player goes through when attacking: run-up, jump, strike and landing. The strike will be discussed in more detail, as it places a particularly high degree of strain on the joint.

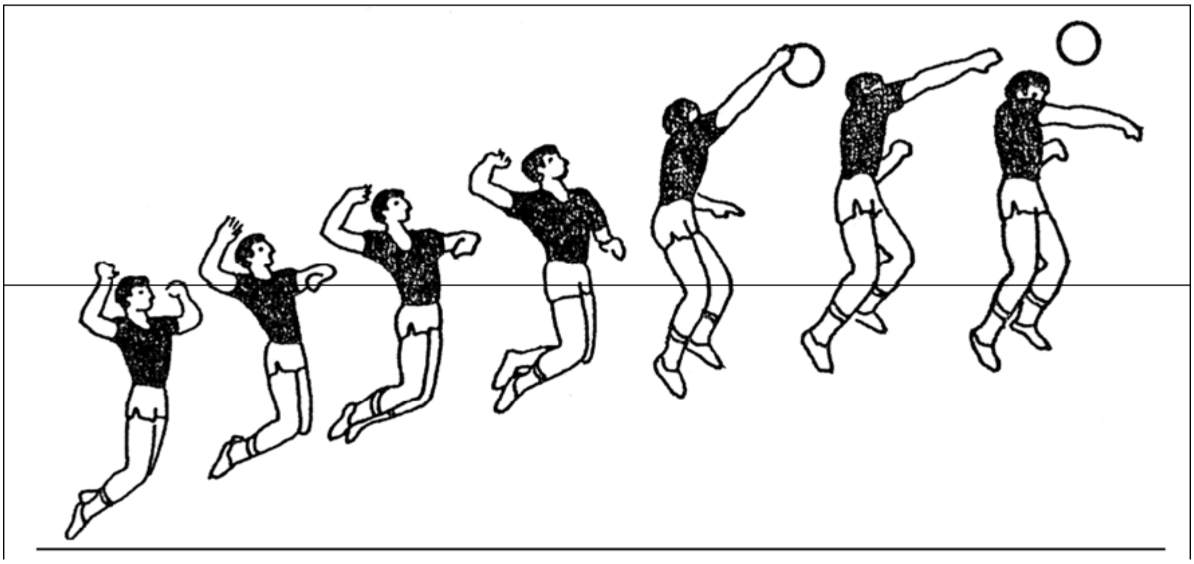


Figure 1: Run-up and striking movement during attack (see Ivoljov, 1984)

As opposed to a striking movement in tennis, the volleyball attack is carried out while jumping. This means that the player has to take into account a further factor in order to ensure that the ball is hit in an optimal fashion. The striking movement is initiated while jumping, by taking the arm back (see Christmann et al, 1997). In this movement, strong players may bend their elbows to less than 90° in order to allow maximum acceleration (see Letzelter, Scholl, Daffner, 1994). When swinging the arm back, the elbow is taken backwards or diagonally at shoulder height. The former method, with external rotation, is more common. While preparing to hit the ball, the elbow joint is not only bent, but, in the case of good players, positioned well below the shoulder axis. This demands a high degree of mobility in the shoulder. Consequently, there is increased strain on the dorsal joint capsule than for players whose joint is held above the shoulder girdle.

Timing and the correct point for take-off greatly affect this action. If the ball is hit 20cm outside the shoulder or with a bent elbow, the height of contact with the ball is reduced by 6 to 7 cm (see Christmann et al 1997). This type of strike leads to different strains in the shoulder joint than one which is carried out with accurate timing and an optimal take-off point. As the position of the head of the humerus changes, so does the strain put on the capsule and musculature.

The technique for striking the ball needs to be varied depending on how it is placed in the opponents' field (see Christmann et al, 1997). In order to send the ball in a trajectory from above downwards during an attack, the angle of the arm to the torso should be between 150° and 170° degrees.

The movement of the arm used for striking the ball is also described as "whipping movement" and has an effect on the technique.   This, together with the height of the action and the accuracy of aim is one of the parameters for measuring the speed of the ball. In order to achieve high ball speed, not only the speed of the hand movement at the time, but also the firmness of the joints in all relevant body parts is crucial. By tensing the muscles the affected joints are temporarily fixated. This allows a more effective transfer of the impulse on to the ball. Top players are able to accelerate the ball to 29.2 m/sec.; for players in regional teams the speed of the ball is around 25 m/sec. (see Willimczik, 1989)

Strain on the shoulder during the striking movement (this section slightly shortened)

As the strike is an important element in volleyball, this movement is practised very frequently during training sessions. Top players repeat the striking movement 40 000 times per year, assuming that they train for about 16 hours a week (see Ballreich, 1992). Every time the movement is carried out, the shoulder joint experiences a force of more than 1000 kp, putting a high degree of strain on the musculature of the shoulder joint and girdle (see Henne, 1997). The stress is concentrated on the sinews of the M. supraspinatus, M. subscapularis, und the long biceps sinew.

The ball can be accelerated to travel at 120 km/h. After hitting the ball, this enormous force needs to be intercepted by dynamic-eccentric strength in the shoulder joint, putting pressure on the rotatory sleeve (see Ballreich, 1992) A high level of concentric activity of the inner rotators and an increased distension of the capsule can lead to considerable complaints.

Muscular imbalance resulting from these strains cause a change in the effect of the related muscles; if this is the case, the joint is unable to reach a state of relaxation and may be subjected to constant stress (see Kremer, 1997)

Common injuries and strains in the shoulder area and the consequences for proprioceptive abilities

Somewhat surprisingly, the frequency of injuries in volleyball is similar to that observed in contact sports, such as basketball, handball or ice hockey. (see Bahr, Bahr, 1997).

There are two categories of injuries observed amongst volleyball players: strain damage and acute injuries. Problems arising during competitions are largely acute injuries. During training, however, strain damage is more frequent and can have painful consequences. 90% of strain damage recorded in volleyball occurs in the shoulder area. To date, an investigation of strain damage has only been carried out in beach volleyball. The type of injury is similar, though on a lesser level. (see Bahr, Reeser, 2003) According to Aagaard strain damage has risen from 16% to 47% over the last ten years; he does not address the cause of this increase. (see Aagaard, Jorgensen, 1996)

The striking movement leads to a change in the scope of the movement range and shoulder joints can display instability; both these conditions can, over time, result in impingement syndrome. Other problems observed are partial or total ligament ruptures, particularly related to the M. supraspinatus or neurophathies of the Nervus supcapularis (often amongst top players).

Figure 2: Relationship between shoulder instability and proprioception (see Lephart et al, 1994)

Propriozeptive Defizite = proprioceptive deficiencies

Verletzung des Schultergelenks = injury of shoulder joint

Instabilitat = instability

Storung der Mechanorezeptoren = defect of mechanical receptors

As the above diagram shows, injuries upset the neuro-muscular balance , the resulting lack of stabilisation can cause receptive trauma and lead on to instability. (see Aygdin et al, 2000) The connection between reduced proprioceptive abilities and damaged shoulder was demonstrated in a study by Machner (1998). Subjects with healthy shoulders, demonstrated no difference between the dominant and non-dominant side (see Aydin et al, 2000; Jerosch, Thorwesten and Teigelkötter, 1997); for those with shoulder injuries, on the other hand, there were clear discrepancies between the damaged and healthy side. They manifest a delay in information reaching the central nervous system and an impaired stabilisation of the joint (see Aydin et al, 2000).

Following an injury, or as a preventative measure, proprioceptive capabilities can be trained, as they are affected by and respond to movement (see Jerosch, Paff, Thorwesten, 1998; Jerosch, Thorwesten, 1998; Rebel, 2000). It is, therefore, essential to take into account the proprioceptive capabilities in the context of prevention and training programmes.

Flexi-Bar and Thera-Band

Regular and carefully thought-out preventative training plans are at the basis of all types of sports. A training programme will be more efficient if it takes into account the demands of each specific sport. Training can take different approaches. On the one hand, it is possible to use the subject's own body weight and to create a variety of exercises. On the other hand, a range of training apparatus can be drawn on. Two training aids will be outlined here and their use in preventative volleyball training investigated. Criteria for the training programmes included:

- Creating muscular balance in the shoulder girdle
- Training the musculature stabilising the shoulder blades
- Stamina
- Quality, rather than rate, of movement
- Inclusion of sport-specific training methods

For the running of training programmes a large variety of aids and training apparatus is available. Each training apparatus has different characteristics and can be used in a variety of ways for preventative training of volleyball players. For indoor training the apparatus must fulfil certain criteria. It should be easy to store and to set up, so that it can be used in every sports hall without lengthy preparations. Both the flexi-bar and the flexi-band fulfil these requirements.

The flexi-bar

The Flexi-Bar

Design of the flexi-bar is based on a device originally used for aiding recuperation of patients with shoulder injuries. This very sensitive device has now been developed into a robust piece of training apparatus which is employed in many fields. It consists of a rod of approximately 150 cm, made of glass fibre enforce material (GFK). Weights are attached at the ends of the rod and there is a grip made of india rubber in the centre (see figure 3)

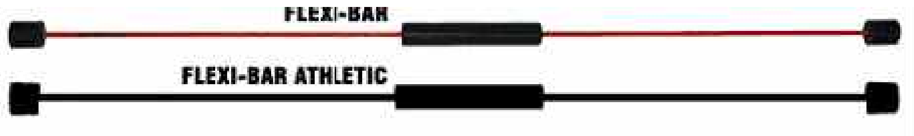


Figure 3: The flexi-bar

During exercises, the flexi-bar is set swinging. The amplitude of the oscillations and the duration of activity dictate how intense the exercises will be.

The force reflected from the end of the rod via the grip to the arm, and thus to the torso area, depends on the amplitude induced by the subject. (see figure 4)

Frequency rate

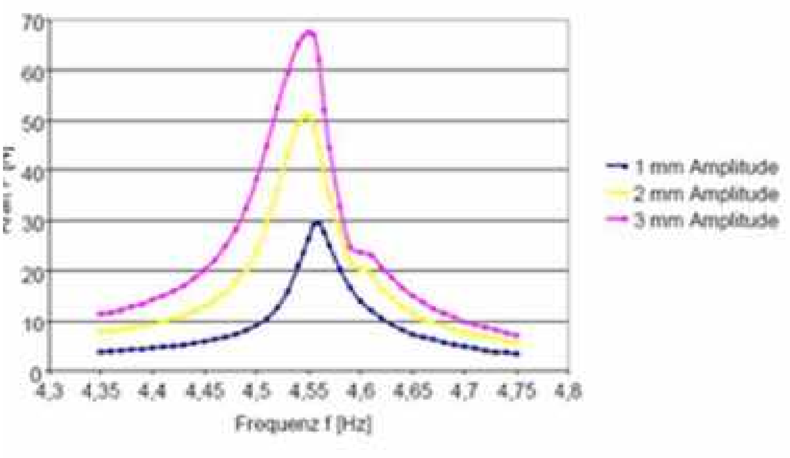


Figure 4: Frequency rate for varying amplitudes (see www.staby.de, 25.1.2005)

The frequency with which the musculature is stimulated corresponds to the oscillating movements per second (see www.staby.de, 25.1.2005).

There are two models of the flexi-bar, the difference lying in the diameter of the GFK rod. The apparatus can thus be tailored to the fitness level of the subject, as more force is required to set the heavier rod swinging.

The Thera-Band

The thera-band is made of latex which has a high elasticity. As the band is stretched, resistance changes in almost linear mode. This band is very versatile, enabling the training of individual muscles or groups of muscles and, depending on the starting position, carrying out complex movement patterns. Colour-coding indicates the different levels of resistance of the bands, so it is simple to adjust to individual levels of fitness. (see table)

Tractive power (in kg) of the thera-band in different colours stretched to differing lengths

length	beige extra light	yellow light	red medium strength	green strong	blue extra strength	black special strength	silver super strength	gold max. strength
50	0.69	1.02	1.58	1.94	2.83	3.39	5.46	7.34
60	0.92	1.12	2.04	2.27	3.39	4.08	6.81	9.38

70	1.12	1.35	2.50	2.73	4.08	4.54	7.88	11.02
80	1.22	1.58	2.96	3.19	4.64	5.10	9.08	12.57
90	1.35	1.81	3.39	3.62	5.46	5.89	10.43	13.87

To allow for effective exercising, the band should measure 200 to 250 cm (see Kempf et al, 1999). Despite being so easy to handle, only few trainers include it in regular preventative indoor training programmes.

Training programme with Flexi-Bar

As opposed to the thera-band, not many exercise routines are, to date, available for the flexi-bar. Nine sets of exercises , based on the criteria outlined above, were designed and details made available to trainers for the duration of the investigation. (note: a list of these should be in the appendix – can be included when editing second part!) The manufacturer's specifications were consulted before setting up the training plan. The intensity of training is initially dictated by the duration of the exercises, then by varying the size of the bar. The duration lies between 30 seconds at the start of training and after changing bars, and 60 seconds at the end of training and before changing bars. The time frame should be chosen to ensure that the quality of movement is maintained throughout.

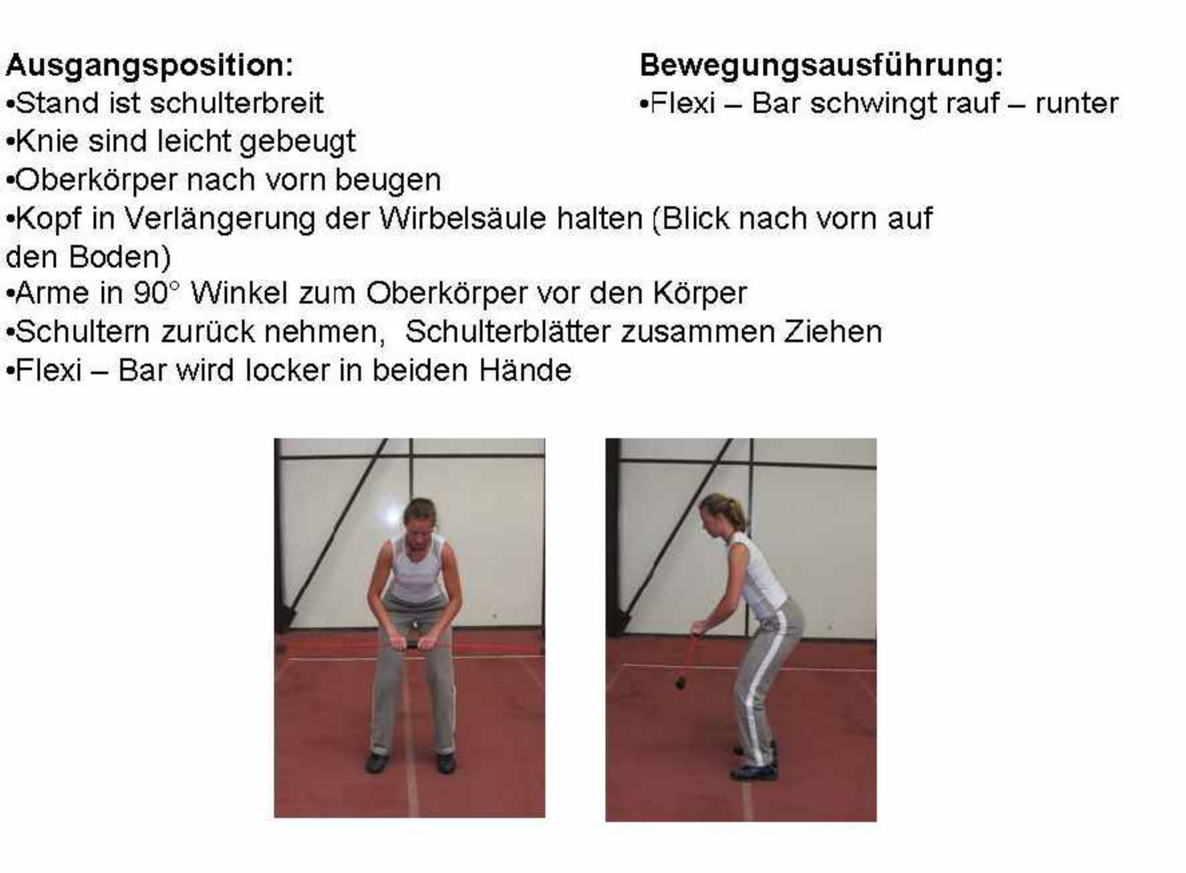


Figure 5: Example of training notes for flexi-bar

Training programme with Thera-Band

As an extensive selection of exercises is available for the thera-band, it was possible to adopt some of those previously used for the German team in preparation of the junior world championships. Due to time constraints, the original plan, developed by Stefan Henne (see Henne, 1997), was shortened to nine exercises for the regional team. The choice focussed on training units aimed at strengthening exterior rotation of the shoulder blade and of the musculature around the head of the humerus.

Figure 6: Example of training notes for thera-band

Design of the experiment

The design of the experiment is outlined below, together with a description of the experimental groups and the training programmes of the teams.

Participating groups

Three of the southern area teams took part in the investigation. One team was training with the flexi-bar, one with the flexi-band and the third continued with the usual training programme.

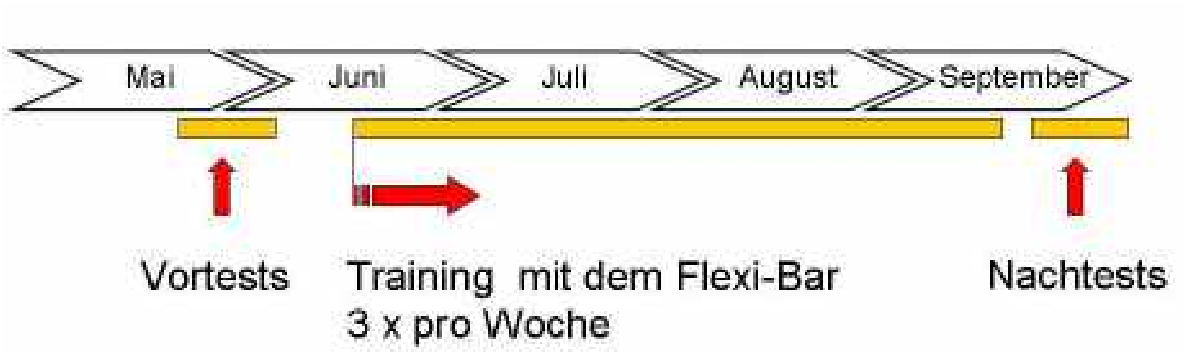
The flexi-bar group had an average age of 22.9 years ± 4.25, the average training age of the group was 9.7 years ±3.56. The average height was 192.67 cm ± 6.185 and the average weight 86.11kg ± 10.787. Nine out of eleven players were present for the follow-up test, as two players were not able to train regularly for health reasons. During the time of the investigation, two players were unable to attend training for a week due to injuries to lower extremities, and a further player was absent for two week due to a dental operation.

The team which trained with the flexi-band had an average age of 28.11 years ± 1.9 and the training age was at 13.56 years ± 3.844. The average weight in this group was 84.56 kg and the average height 186.11 cm ± 4.256. During the training period in question one of the players was absent for three weeks due to a pulled ligament in the thigh. A further player was unable to attend the follow-up test for personal reasons.

The average age of the control group was 28.43 years ± 6.803 and the training age 13.29 years ± 5.024. The average height was 190.24 cm ± 4.768 and the weight was 87.43 kg ±5.224. During the training period three players were absent due to injuries, two of them with injuries to the toes, one with a fracture of the right hand. In this group one player suffered from a shoulder injury; this was a ligament tear of the magnitude Toss I on the right side. The player did not acquire this injury during training or a game. All participating players completed two to three weekly training sessions, lasting two hours at a time.

Plan of the investigation

The study includes an initial assessment and a follow-up investigation. The teams which participated were examined at the start of the preparatory phase for the 2004/2005 season and at the end of the preparatory phase. The training phase was fixed at three months; according to the manufacturers this is the minimum time required for the flexi-bar to have a noticeable effect.



Vortests = initial tests

Training... = training with flexi-bar 3 times/week

Nachtests = follow-up tests

Figure 7: Time scale

The training programme was based on specifications from and in consultation with the trainers.

The teams which worked with the flexi-bar received an extensive introduction to the equipment so that the players and the trainer were able to follow the training programme independently. The exercises were integrated into a plan in which power training for the lower extremities alternated with flexi-bar exercises. If there were fewer than three training sessions per week, the players also used the flexi-bar at home. At the start of the programme, the standard flexi-bar was used for training. After approximately two weeks, the standard flexi-bar was replaced by the flexi-bar "athletic". This was necessary, as coordination of the oscillations o f the equipment had improved so much that the amplitude of the oscillations became too large. For training with flexi-bar "athletic", time spent on the individual exercises was reduced by 30 seconds. Without this reduction ,the intensity of the exercises would have been too high and the parameters of an endurance training would not have been fulfilled.

The team which carried out the training programme with the thera-band had already worked with this, so no particular introduction to its use was necessary. The trainer received a short induction to the exercises of the training programme which he included into the training in one block.

During preparation, the control group used other training equipment which happened to be available, for example medicine balls. The focus was on performance-related musculature . The training was carried out in rotation. For work on the lower extremities, the trainer also included exercises on instable surfaces, in accordance with proprioceptive training principles. This approach was, however, applied exclusively to the lower extremity.

The investigation

To examine the proprioceptive qualities of the upper extremities is a complex task, as the diverse senses which make up the proprioceptive capabilities demand different types of tests. A further problem is how to comprehend the quality of the humerus head. In the following section, the stages of testing which were used for preliminary and follow-up tests are outlined.

Preliminary considerations for the test series

As there are hardly any testing procedures available for diagnosing performance, the first step was to devise a method for testing the individual senses.

In the available literature, (Jerosch et al, 1996; Jerosch, Thorwesten, 1998; Jerosch et al, 1997; Aydin, 2000) only one sense within the capabilities is investigated. The experiments are based on reproducing angles and are designed to study the sense of position. These investigations were carried out within different experiment designs.

In order to study the sense of position, it was possible to use the underlying design of previous exploration. As mentioned, the simulation of an angle is used to register the sense of position. The test procedures which had been applied in other studies were very varied and could only be reproduced with great difficulty; they were not always suitable for preliminary and follow-up measurements, as they involved attaching markers. (see Jerosch, Thorwesten, 1998; Jerosch et al, 1996). Therefore an alternative had to be found. The aim was to devise a test which would be suitable for preliminary and follow-up measurements and which could be run without complicated apparatus. One test which can be completed without major effort is that which tests the sense of position of the subject with the use of a punching mask.

The sense of strength is discussed in the literature (see Weineck, 2002; Jerosch et al, 1996) but there is no measuring procedure mentioned which uses this parameter as criteria for the quality of proprioceptive capabilities. However, this sense is part of the treatment which is used for shoulder injuries, as the input of force is an important aspect of well coordinated movement. During therapy there are various approaches used. One possibility is training with a pulley, which was used as the basis for developing a system for measuring the sense of force.

An additional problem which has not yet been included in the measuring techniques, is the ability to centre the humerus head, in which the muscle-body sense plays an important role. Efficient follow-up regulating is conditional upon the musculature of the rotator cuff. During a movement. the regulatory process needs to be reflected in the measuring technique. Following a sudden movement, a re-balancing takes place and this needs to be taken into account in the measuring process. The mechanism used to study the ankle joint uses a similar approach (see Lohrer, Alt, Gollhofer, 1999).

In order to obtain information about the functional state of the subjects' shoulders, clinical tests were included, as these provide data about the condition of the shoulder and allow us to establish any possible injuries or serious overloading damage (see Boenish, Lembcke, Gröger, 2001)

Through isokinetic tests possible muscular imbalances should be discovered and monitored throughout training. This should provide information to what extent flexi-bar affects strength and how it differs from the effect of the thera-band.

Subjective impressions are a further parameter which can lead to interesting insights. For this reason, a subjective questionnaire was also devised, as questionnaires are mostly used for a specific situation, for example to follow the healing process after a shoulder operation. (see Oppelt, 2003) The questionnaire was adapted to the particular needs from that designed by Professor Imhof. Based on these considerations, the measuring procedures for the tests were devised or chosen.

The test series

The sequence of the tests is not identical with the sequence of their implementation. Each subject was given the sequence in which the tests were to be carried out on the days in question. This sequence remained the same for the follow-up tests. Before undergoing the tests, subjects were encouraged to do warming-up exercises with particular regard to the shoulder area. No outside interruptions could influence the tests and there were no distractions which could have had a negative effect on levels of concentration.

The test series contains five measuring points and a questionnaire. Three measuring stations were developed for this specific investigation: the ball test, the rope/pulley test and the punching mask.

Description and implementation of the ball test

The ball test was newly developed for this investigation. On the one hand, this test measures the time taken for a subject to balance out a mechanical deflection and to re-establish the original position. On the other hand the test shows how well the initial or starting position can be reproduced.

The deflection is triggered by a spring which in turn is stretched by a lever. The ball, which is mounted on a pole can be tilted by 32^{0} via a ball and socket joint. The components of the test are mounted on a plate which is fixed to coasters. The plate is connected to the lever in order to deflect the ball.

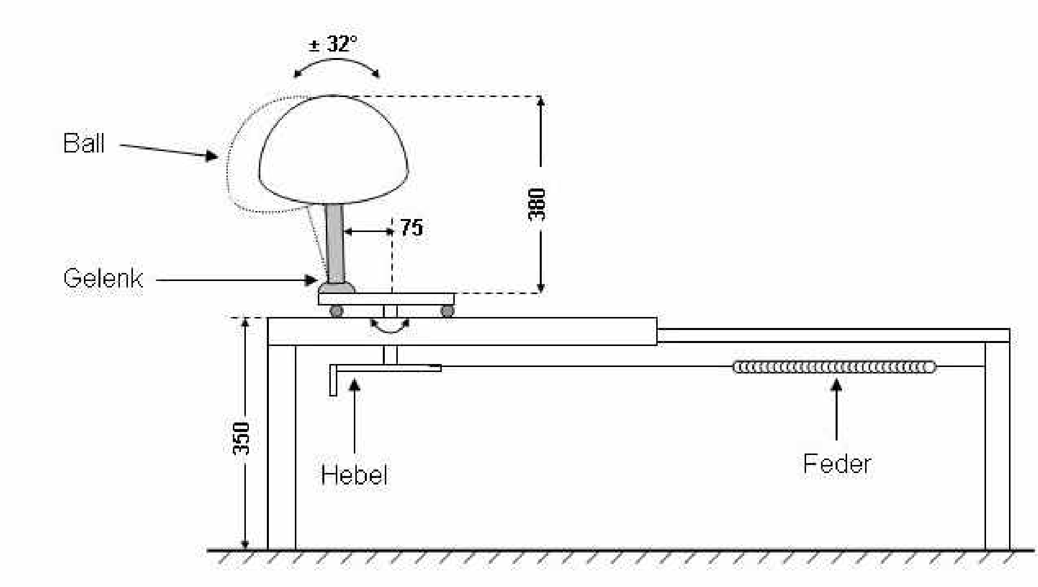


Figure 8: Schematic representation of the ball test

Gelenk = joint

Hebel = lever

Feder = spring

For the experiment a double-axel gradient measuring device was used (SCA111T-DOF, produced by Pewarkran AG in Munich) which has a sensitivity of $70mV/^{0}$. The sensor is placed under the ball. In order to ensure that subjects put equal pressure on the ball, a spring is inserted into the pole carrying the ball. Two sensors are mounted on the pole and give off a signal if too little or too much pressure is exerted on the ball.

This installation is placed alongside a box on which the subject lies on his or her front. The shoulder needs to have space to move and the arm-torso angle is 160°. The elbow should be slightly bent in order to avoid over-stretching the joint. This position of the shoulder and elbow correspond to that used when the ball is hit. (see Kugler, Krüger-Franke, Reininger, Trouillier, Rosemeyer, 1996) The distance from the box to the table varies depending on length of the subject's arms, so that the ball always stands vertically above the ball and socket joint.

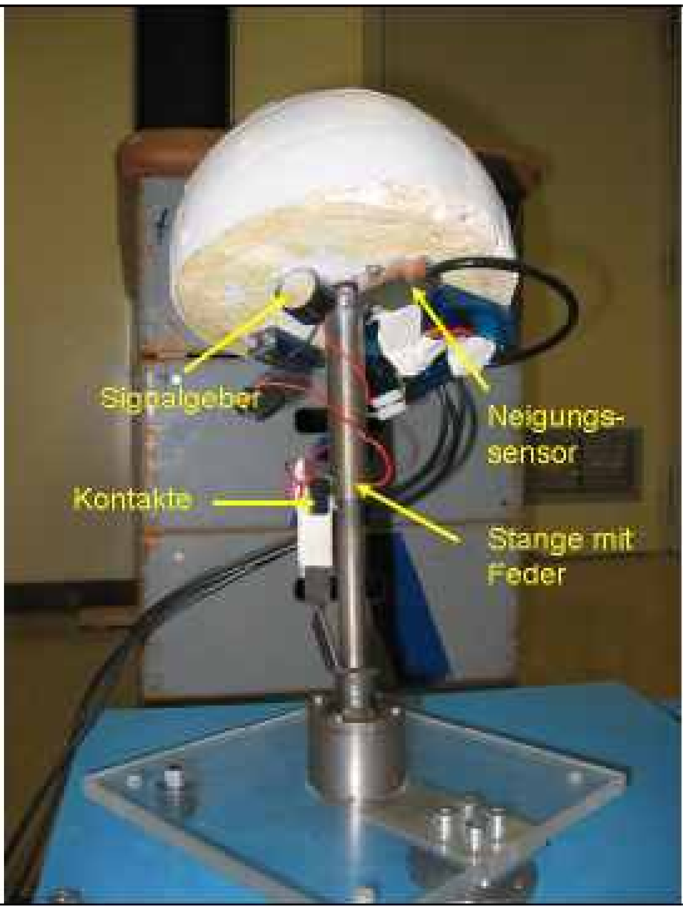


Figure 9: Set-up of the sensor

Signalgeber = signal

Neigungssensor = gradient sensor

Kontakte = contact points

Stange mit Feder = pole with spring

Figure 10: Positioning for ball test