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Long and triple jump training on pneumatic run-up surfaces

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ABSTRACT

The attainment of a sports performance is always dependent on the stabilization of movement skills (technique). However, at the same time this stabilization impairs the further increase of performance in athletes. That is why variability in training organization is sought after. This applies to the long and triple jump, too. An excellent means to enable variable training in these two events is a new surface for the run-up: the pneumatic surface, which consists of rubber and air cells. This surface allows athletes to carry out more run-ups of maximum length without fatigue symptoms of note. This is made possible through the reduction of impact loads and the increase in muscular work efficiency. The reduction of impacts loads creates favorable conditions for the active work of the support and movement apparatus during the push-off with maximal intensity. At the same time this enables the athletes to increase the amount of jumping exercises with an increased intensity. In an experiment the influence of the pneumatic surface on the effectiveness of the muscle activity was examined. It turned out that this surface enables the jumper to utilize his or her power potential to the maximum. The athletes noticed that the reduction of the impact load on the support and movement apparatus facilitated the interaction with the support area. At the same time the athletes had the subjective feeling of reduced fatigue. Most importantly, the athletes did not suffer from pain in the hip and knee joints during high-intensity jumps.

The result shows that the reduction of the impact load and the recuperative characteristics of the pneumatic surface enables athletes to perform a higher number of jumps from a full run-up. The greater number of jumps enables a reliable development of jumping technique for jumping distances that are even beyond the respective athlete's personal best performance. The pneumatic surface can also be used for the training of athletes with light injuries of the support and movement apparatus or for training during the rehabilitation phase after an injury. In this way top form can be maintained and the time needed for regeneration can be shortened.

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1 Problem...

Traditional methods for the preparation of long and triple jumpers are not always useful. This is particularly obvious in the area of top-level sport. There the principle of variable training loads plays a decisive role when contradictory training tasks must be solved. On the one hand the attainment of a certain sports performance requires the stabilization of movement skills (technique), but on the other hand this stabilization impairs further improvement in athletes' performance.

This contradiction can be observed in the long and triple jump.

2... and possible solution

We see a possible solution to this problem in the rearrangement of the number of jumps in favor of jumps from a long approach run. However, this is difficult to achieve under normal conditions. A way out of this dilemma can be the use of the pneumatic run-up surface, which was developed by B.S. and V.S. Saweljev, V.G. Zaikin, and A.V. Bondarjov (Zaking/Saweljev/Sutschilin 1982).

The pneumatic surface consists of rubber with a lot of air cells, which are embedded in a soft tissue layer and which are supplied with air by channels running from cell to cell. Air is pumped into this air conducting system by a compressor at variable high pressure. The working area of the pneumatic surface, on which the athletes perform their run-up, consists of a fine rubber layer, which is put on top of the soft tissue layer.

By changing the pressure in the cells (which can be measured by a manometer) the hardness coefficient of the pneumatic surface can be varied from 0 to 20.104 n/m. The individual pneumatic surfaces for the training of the jumpers have a length of 5m each and can be put together to form a run-up track.

Since the elasticity of the surface has a significant effect on the execution of the jumps, the regulation of this parameter taking into account the individual characteristics of each jumper is very important.

For determining the impact force on the movement and support apparatus of the athletes during different jumping exercises the following experimental design was used: The forces during a drop-jump from a height of 70cm with a subsequent vertical or horizontal jump and the forces during a long jump from a run-up were measured. The jumps were performed on a standard surface and on the pneumatic surface. The acceleration at the ankle and knee joints during the jumps was measured using accelerometry. Twenty-two athletes took part in the investigation.

3 Results

The analysis of the data shows that during the push-off from the pneumatic surface there is a significant decrease of impact forces acting on the athletes' support and movement apparatus (1.5 to 2 times lower) at the moment the foot is placed onto the point of support (Fig. 1). This can be explained by the elastic defor-

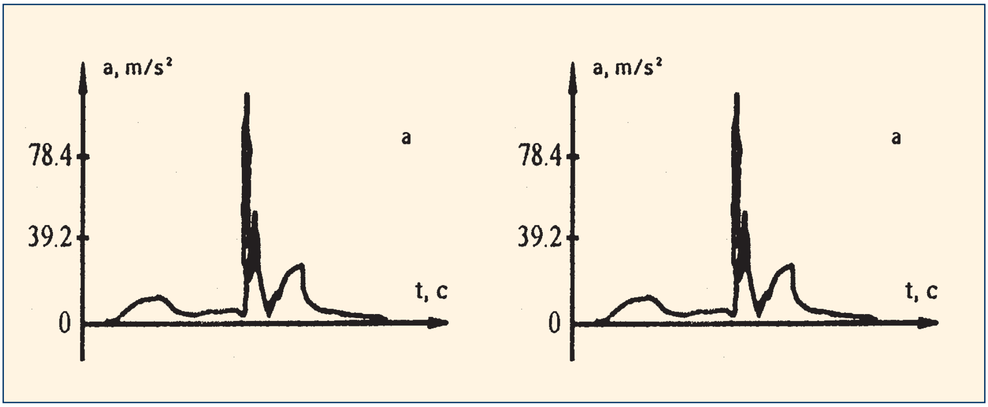

Fig. 1

mation of the pneumatic surface, which leads to the increase of the contact area between the foot and the point of support (pneumatic surface) and to the simultaneous decrease of the partial pressure acting on the foot.

The decrease of the impact forces creates favorable conditions for the active work of the support and movement apparatus during the push-off with maximal intensity. An additional consequence of this decrease is that the amount of jumping exercises with higher intensity can be increased.

For the determination of the mechanical effectiveness of the push-off/take-off from the pneumatic surface a comparison of the energy consumption during identical work (vertical jumps, hand at the hips) was conducted on a standard surface and on the pneumatic surface.

The influence of the pneumatic surface on the effectiveness of muscle activity was examined. In addition to this the numerical values representing the interaction of the jumpers with the differently elastic features of the support areas were of interest.

The following methods were used:

Indirect calorimetry (“Bekman” gas analyzer) and biomechanical kinematography. Seven male athletes took part in the study. They carried out vertical jumps in series of 4 minutes each. Each individual test was preceded by a resting period of 10 to 15 minutes duration to guarantee the regeneration of the functions of the organism after the warm-up.

In Table 1 the results of the investigation are presented; they relate only to the major characteristics of the jumping series. The coefficient of mechanical effectiveness (CME), which characterizes the relationship between the mechanical work done and the metabolic energy consumption, was calculated. In this context, only the work during the “overcoming” phase of movement, the so-called positive work, was measured. In the training session, the decrease of impact force and the increase of muscular work efficiency enables the athletes to carry out more (twice or two-and-a-half times as much) jumps from a full run-up, without the athletes showing considerable symptoms of fatigue.

4 Analysis of the long-jump technique

The technique of competition jumps from the standard and the pneumatic surface was analyzed using biomechanical kinematography (“Actionmaster 500” film camera, “NAC Sportias” film analyzer).

When comparing the movements of the athletes’ center of body mass (CBM) it was determined that the changes of the vertical velocity component are quite different. During the push-off from the pneumatic surface the vertical velocity component of the CBM increases at a faster rate and reaches higher values (Tab. 2). This happens at the moment when the jumper’s body is approaching the vertical position and is accompanied by fewer changes of the angles at the knee and hip joints. Here the efficiency of accumulation of energy and its subsequent discharge

Table 1: Energetic characteristics of jumps on different surfaces

Characteristics	Standard surface		Pneumatic surface	
Athlete’s weight (kg)	76,5	2,65	76,5	2,65
Number of jumps in min	102,9	9,96	104,6	6,42
Positive work during one jump (in joule)	194,4	8,05	195,2	9,60
Metabolic energy consumption per 1 kg and 1 jump (in joule)	6,3	0,89	5,1	0,53
KME, %	29,35		36,60	

Tab. 1

depends on the degree and velocity of stretching of the active muscles. In the jumps with low amplitude and high stretching velocity the efficiency is greater than vice versa (great amplitude and low velocity).

In other words: The greater the negative power, which is developed during the reduction of the distance between the hip joint and the center of pressure, the greater is the positive power, which is created during the increase of this distance (Priluzkij 1990).

Consequently, the kinematic differences that we identified indicate that the use of the pneumatic surface enables a more efficient execution of the push-off in the long jump. This is also indicated by the structural transformation of the take-off and the results of the jumps. It remains to be noted that the angle of inclination (touchdown angle) of the take-off leg, the degree of resistance during the amortizing bending at the joints, and the activity of the extension determine the duration and direction of the strength efforts which the athletes develop at the take-off with identical run-up velocity. If the take-off leg touches down far in front of the athlete's body (small angle of touchdown) with small amortization, this causes an increase in the magnitude and effect duration against the forward movement of the body. Here, the jumper starts the extension too early if his or her body is very far behind the point of support. Although this leads to a very great angle of take-off and to a greater height in flight, it also causes significant losses in forward momentum (e.g. horizontal velocity).

Both a touchdown of the foot too close in front of the body (i.e. with an obtuse inclination angle between the take-off leg and the take-off surface) and a deep amortization (more than 10 degrees at the hip joint and 40 degrees at the knee joint) lead to a late extension and therefore shorten the time the force can be efficient. This again causes a shortening of the flight distance because of the unfavorable height.

In the course of the experiment it turned out that the pneumatic surface helps the jumper to utilize his or her speed-strength potential to the full. On the other hand, the pneumatic surface impairs this potential in the case of technical faults in the jumps.

5 Testing of the pneumatic surface in training

Eight highly qualified athletes took part in the experimental testing of the positive effects of the pneumatic surface during training. The experimental group consisted of five subjects while the control group included three subjects. The athletes of the experimental group trained on the pneumatic surface while the other subjects trained on a standard surface.

Before the experiment the individually most favorable elasticity parameters of the pneumatic surface were determined for each athlete, i.e., it was determined which elasticity was necessary for each athlete to develop his or her maximum speed-strength (i.e. jumping power). The athletes performed the long jump from a standing position from different surfaces.

Each athlete had three attempts for each value of air pressure in the air cells of the surface (0.5 – 0.6 – 0.7 – 0.8 – 0.9 – 1.0 atm). The individual values of elasticity of the pneumatic surface were determined using the best result (Tab. 2).

It is well known that the performance of long and triple jumpers depends on their ability to take off with maximal velocity. Since jumps from a long run-up require maximal strength efforts and are done at maximal velocity they place an extreme stress on the nerve and muscle apparatus.

In the experimental training using the pneumatic surface, up to 70% of all jumps were realized from a full run-up. The athletes noticed that the reduction of the impact load on the support and movement apparatus facilitated the interaction with the support area. This created better conditions for an active take-off, which the athletes felt through a higher muscle tension. According to the athletes' subjective impressions there was a reduction of the fatigue of the support and movement apparatus. Furthermore, the jumps with high intensity did not cause pain in the hip and knee joints.

Athlete	Results before the experiment		Results after the experiment		t	P
	maximal	x ± SD	maximal	x ± SD		
Experimental group						
1. G-w (MS)	7,38	7,23 ± 0,10	7,55	7,45 ± 0,06	4,13	0,001
2. M-w (MS)	7,12	6,99 ± 0,10	7,38	7,25 ± 0,07	5,18	0,001
3. L-a (KM)	6,08	5,94 ± 0,09	6,31	6,21 ± 0,08	5,38	0,001
4. S-i (MS)	15,70	15,54 ± 0,10	15,74	15,55 ± 0,14	0,45	0,05
5. G-v (KM)	14,20	14,01 ± 0,14	14,75	14,48 ± 0,17	5,26	0,001
Control group						
1. T-n (MS)	6,55	6,38 ± 0,10	6,43	6,30 ± 0,08	1,52	0,05
2. D-a (MS)	6,14	6,00 ± 0,09	6,23	6,11 ± 0,12	1,74	0,05
3. M-w (MS)	7,33	7,21 ± 0,09	7,37	7,27 ± 0,08	1,22	0,05

Explanation: MS = Master of Sport; km = Candidate for Master of Sport

Table 2: Long and triple jumps

The results of both groups before and after the experiment are presented in Table 2. The data of six attempts of competitions before and after the experiment are compared.

6 Practical conclusions

The use of the pneumatic surface has proven useful with the following exercises in the training of long and triple jumpers:

- running with rests in the support phase,
- depth jumps with subsequent long jump or jump over a hurdle,
- bounding,
- hop jumps on the take-off or swinging leg,
- two-legged jumps one after the other (frog jumps),
- jumps on the spot or of a distance of 1.5 to 2 m with drawing one knee or two knees to one's breast,
- one-legged or two-legged jumps over hurdles,
- take-offs forward and upward after three to five running steps each,
- taking off from and jumping onto different support areas,
- long and triple jumps from run-ups of different length.

The use of the pneumatic surface leads to the following positive effects:

- greater variability of the exercise conditions,
- individual choice of the elastic characteristics of the pneumatic surface, determined by the athletes maximal speed-strength;
- significant (i.e. by half) reduction of the impact load on the support and movement apparatus at the moment of touchdown onto the support area;
- increase in the energetic effectiveness of the muscle work by 7 to 8 percent;
- transformation of the rhythmic structure of the movement action in the take-off phase, which leads to a shortening of the duration of the yielding (eccentric) muscle work and to a prolongation of the concentric muscle work;
- increase (one-and-a-half to twice as much) of the amount (the number) of jumps with maximal intensity (96 to 100 per cent) through reduction of the jumps from a short run-up;
- increase in sports performance.

When using the pneumatic surface, the regulation of the elastic characteristics of the surface deserves special attention because it can be adapted to the different tasks of the training types in the macrocycle. Of course, the individual determination of the elasticity of the surface is always to be recommended on the basis of the athlete's maximal speed-strength (jumping power). The extension of the variability of the jumper's interaction with the support area (surface of the run-up and take-off facility) leads to a higher stability of the jumping technique. By regulating the elasticity of the pneumatic surface the coach can create more difficult or simplified jumping conditions. The reduction of the impact load and the recuperative (energy-conserving) characteristics of the pneumatic surface enable a higher number of jumps from a full run-up in training. For triple-jumpers, who in their technical training seldom carry out the complete competitive exercise, such jumps become a normal training means. The number of jumps from a short run-up decreases so that the total amount of jumps remains unchanged.

An increase of the repetitions of the complete competition exercise enables a reliable development of the jumping technique over distances that are even better than the personal best performance. During the technical training with the pneumatic surface the athlete must concentrate on the active work of the support and movement apparatus, i.e. on the fast movement of the jumping leg, in order to immediately start the active extension of the take-off leg (i.e. to shorten the amortization phase).

This way the athlete achieves a more intensive take-off and consequently an improvement of his or her jumping performance. It is a well-known fact that serious mistakes make the execution of the jump more difficult because false techniques lead to the prolongation of the take-off action or to a non-synchronized strength effort. If, however, the technical characteristics get close to the model characteristics of a concrete jumping performance, the pneumatic surface additionally supports the take-off. So there is a direct regulation of the athlete's interaction with the support area depending on the elastic characteristics of the run-up/take-off surface. Moreover, multiple repetitions of the complete competition exercise from a full run-up on the pneumatic surface do not lead to a fast fatigue of the support and movement apparatus. In this way, target-oriented work on the refinement of the jumping technique is made possible.

7 Final recommendations

The increase in the amount of jumping exercises with maximal intensity opens up new possibilities for the complex refinement of the state of technical preparation and special conditioning.

In the course of the training process pneumatic surfaces must be used in combination with the standard surface in indoor sport facilities (in a ratio of 1:1) because the conditions for interactions with the support are not only varied via the elasticity but also via the type of surface. With increasing training state the relation shifts in favor of the jumps from harder support areas up to the complete change to the standard surface in indoor facilities.

Triple jumpers should use the pneumatic surface for the execution of all three partial jumps (or for corresponding interactions with the support).

The pneumatic surface can also be used for the training of athletes who have mild injuries of the support and movement apparatus as well as during their rehabilitation phase. This way top form can be maintained and the duration of the regeneration can be shortened.

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