

## Biomechanical analyses of the high jump technique (Wolfgang Killing)

The high jump contains the straight and curved run-up, the takeoff preparation, the takeoff, the flight with the bar clearance and the landing. The high jump is a takeoff as all athletic events. "Takeoff" means after a more or less long resp. fast run up to jump from one leg. The muscle work in the takeoff is reactive, first concentric, then eccentric, in a short contact time (0,13-0,18 s). In a takeoff the athlete uses the free leg and the arms for a swinging support. Takeoff means also, to change the run-up horizontal speed partly to vertical, so the jumper produces a takeoff angle. The optimal takeoff angle in high jump is 40 degree, so there is a big change of direction resp. a high force on the takeoff-foot.

Therefore in high jump we do not have to produce a maximal, but an optimal approach speed, which the athletes normally reach with 5 to 10 run-up steps. In the flop style we do 2-5 strides in a straight way and the last 3 to 5 strides as a curved run-up. From a bird's view the approach looks like a "J", its curved end, the takeoff-position should be positioned in the first third of the bar length. From the beginning to the first but last stride there is a continuous acceleration. In the first strides the body is in an upright position or slightly forward body lean comparable to a 400m-sprinter. This position will be kept in the curve, but in addition the curved run produces an inward lean of the whole body.

The last two steps of the run-up are called takeoff preparation. The body keeps its inward leaning but leaves its forward lean position and changes it continuously over an upright to a back layout position at the beginning of the takeoff, the so called touchdown of the takeoff leg. The back layout includes the body and the takeoff leg, so they both build a straight line or lever.

By this double leaning in the moment of touch down the center of mass is lowered and the vertical acceleration can start. This happens by three synchronized activities: The back an inward leaning lever raises passively, the jumping muscles of foot, knee and back muscles contract intensive, the arms and the free leg swing first forward then upward. By this action the body raises and changes the horizontal to vertical energy, so at the end of the takeoff the leg-body-lever is in an upright position, the swinging arms and free leg reached a high end position, so the center of mass is high and depending to the vertical impulse the body has a high vertical speed, but also a rest of horizontal speed. Meanwhile the take of the free leg swings not straight but diagonal to the inside of the curve, the trunk turns a bit to the inside direction and also changes from the inward lean to the vertical and may be the shoulders lean a bit more to the bar. All these produce a complex rotation momentum, so the body rotates after the takeoff with his backside to the bar and also from a vertical position to a horizontal position over the bar. The higher the bar, the more time the athlete has to come to this position.

Over the bar the athlete can stretch and overstretch his hips to an arch, which makes his/her bar clearance more effective and allows the athlete, to reach a better result with the same takeoff impulse. After the hips have passed the bar in horizontal direction, it should be lowered by contracting the front body muscles/abdominals, so the upper legs are lifted and can also pass the bar without touching. Finally the athlete kicks out his lower legs and feet, come to the L-position and lands safe on the round back and shoulders.

All these aspects of the high jump technique will be demonstrated by videos, photo sequences, graphics and biomechanical data of high jumpers from youth age to world class level.

### Technic training for young high jumpers (Wolfgang Killing)

High jump beginners normally do not start directly with the flop style, but with learning the takeoff as a one-leg-jump after a short run-up. At the beginning they will do the takeoff with the right and with the left leg, so you can find out the jumping leg. This should happen in kid's age by general exercises and in the long jump. So you can build up on it later. Also in kid's age I start teaching the scissor style with the right and with the left leg from a five-step-approach. This stabilizes the unity of run-up and takeoff. In the scissor style I take care

- For a starting mark, a continuous acceleration and a stabile run-up pattern
- for a full stretching of the takeoff leg and the body
- for a bended free knee, which does not overtop the hips
- for a flight path forward-upward, landing on the non-takeoff-leg, keeping the speed
- for a low, not too weak high jump pit, so the sportsmen can keep forward moving

My methodical sequence for the flop style starts with the takeoff and has only a few steps:

1. Takeoff (scissors) from a straight five-step-approach on a high jump pit, fly far forward
2. Like before, but from a curved five-step-approach marked with little plastic signs
3. Like before but meanwhile take-off turn your free leg inside, rotate and land on your back
4. Like before over a low bar or rope
5. Like before by a rising bar
6. Like before with a two steps longer approach
7. Active foot plant in the direction of the run-up (no turn away the foot from the pit)
8. Overstretching the hips over the bar

On every step I do some repetitions to stabilize the movement pattern. By doing the exercises I give typical corrections to lead the move in the intended direction. In the group situation I try to point out advices with an effect to all athletes, which means I normally give positive supports/advices. For the same reason I praise good presentations. Every next step means a new learning task. This can confuse the athletes, so maybe you will go back to the step before, stabilize the move and then try again the next step.

For each step I have some supporting and simplifying exercises to help the athletes on their learning way. These exercises can have a technical, a coordinative or a conditional focus. Every step of the methodical sequence and also the supporting moves are training exercises, which improve f. e. jumping power or body strength. So you have to understand and handle the training by a conditioning aspect, which means to take care about load and recovery.

Normally high jump training with groups is not too intensive by the conditioning view, often it is just the opposite, so I try to organize it as an "assembly line", in which all few seconds an athlete can start his/her run-up. Therefore I put the bar on low heights and rise it carefully, so everybody can jump over without touching. Also therefore I avoid individual corrections, but point out good examples. Good organized you can have an effective training including 15-25 jumps for each with ten, may be 12-15 athletes at once. If you have more athletes than this, you should divide the group into parts.

On a foregoing level the groups should be smaller, to give more individual corrections. By this you will find out also individual elements of the technique like the length of the approach, the radius of the curve, the distance to the bar, the kind of arm swing support and the abilities of arching by clearing the bar. Respecting a lot of individualities I prefer a training on low to middle heights (till 20 cm, maximum 15 cm below PB) with only very few miss-attempts.

### General strength, jumping and plyometrics for young athletes (Wolfgang Killing)

The most important abilities of jumpers are the specific and the general jumping power resp. the leg strength. These are also very important qualities for the heptathlon and decathlon, for the sprint, the hurdles and the throwing events. Even the long distance runners, specially the steeple chasers need jumping power. So in training we spend a lot of time improving jumping power and general strength.

First I will present jumping/bounding exercises. Therein I distinguish seven ground forms, which each include a lot of exercises and can be done under different conditions, which matters the training effects and responses.

Name	Description, varieties	Training placement	Training volume
1. Jumps from a standing position	After each jump new start almost concentric work Both leg, on leg, on a box, ..	Starting training year, in circle training, Useful after injuries (only concentric muscle, no joint load)	0-2 sessions/week 20-100 repetitions (a bit boring train.)
2. "small" jumps	low to middle intensity, focus on coordination, one or both legs or in combination, for-, side-, backwards,	All year at the beginning of a training session learning different intensities utilization after weight training	Each training like sprint coordination  6-8 x 10-20 m
3. Skip-jumps	l-l-r-r-ll ..., Simple ground form reduced speed, good control variety in direction, intensity	helpful for learning technical elements, like foot plant or arm action many repetitions possible	Each training (alternating to small jump)  6-8 x 20-30 m
4. Both leg jumps in series	Quarter, half or deep squat Horizontal or vertical direction, overith hurdles, from boxes reactive effects	After some weeks of training in general preparation, rising intensity depending on abilities, Plyometric (deep) only for adults	0-1 session/week  1-2 x 5 x 5 hurdles
5. Alternate bounding	Simple ground form, "longer step", earl learned Active leg-/foot-plant From standing or with run-up	Possible whole training year Starting from standing / uphill Later flat ground and with 3 steps Volume depending on intensity	1-2 sessions/week (alternative to both leg bounding) 1-2 x 5 x 5-10 jumps
6. One-leg-bounding	Complicated ground form, different balance, start standing, then with low speed,	Only for foregoing athletes and in special preparation, careful with speed and volume, good in combination with alternate bound.	0-1 session/week  each leg 1 x 5 x 5 J.
7. Take-Offs	Jump with one leg from run-up, on boxes, over hurdles, to high targets, free, 1-5 steps in between the jumps	special preparation and competition time, Special exercise for preparing the event techniques (cross leg and arm coordination)	0-2 sessions/week  each leg 1 x 5 x 3 TO

The sex differences between boys and girls affect the jump- and weight training a lot. Girls mature earlier, in the age of 13-15 years they have some weight gain becoming women, so the weight-strength-relation changes to negative. To compensate this natural development, they should start in the age of 13 with strength- resp. weight training, and improve this to two times per week till 15 y. By the same reason they have to be more careful with jumping, especially bounding training, otherwise the joints will be overloaded. This means, that girls should do a less intensive jumping training with a lot of "small jumps" and avoid plyometric and one-leg bounds.

The boys mature later and improve their weight-strength-relation till the age of 17-18 years. So there is no early need for intensive weight training. They will have an optimal improvement with normal (middle intensive) jump- and bounding training. Because the joints, tendons and ligaments are still weak, plyometric training and bounding with fast approach should be done later, in grown up age. Like the girls the boys should start learn weight lifting techniques early (12-13 y.) and keep this in training once a week or once a fortnight till age of 17 y. only for coordinative and technical aspects. While the girls rise the intensities beginning with 13-14 y., the boys should start with 17-19 y. (exception throwers).

### Specific high jump training: Various techniques and training regimes (Wolfgang Killing)

The name “flop” includes, that the high jump in it’s rough form is a not so complicated technique. By the rising height it will be not only more intensive but also technical challenging. To prepare this, we do a lot of variation in the specific technic training, inside the flop style, but also by using different high jump techniques.

As mentioned in the former lessons, I prefer to start the high jump with a mix of the normal takeoff and the scissor style. Scissors are a good entrance to nearly every high jump training and also in the warm-up before competitions to test the run-up by a low bar height or even without a bar. To make sure that the takeoff times will not elongate, I use the scissors normally with the flop run-up, with a short, bended driving leg, and a long flight path. Because in scissors you have no rotation, it is a very good exercise for both legs. Often I use it alternate, one jump with the right leg, the next with the left, put the bar higher and so on. Even not testing out the whole capacity of this technique, the results will improve by use. I normally start with very low heights and raise the bar may be five times. If the athletes do all heights including the last very easy, I will start next time a bit higher or do bigger steps. In general I try to avoid miss-attempts in training.

After the entrance with the scissor style I change to the flop. I do this every time after lowering the bar, so the athletes have again an easy entrance to the flop and are able to concentrate on the approach, the short take off and a long flight pass landing far and save on the pit. In a normal technic training I would raise the bar and give some correction advices, but in preparation time I often do variations of the flop like passing the bar in a sitting, not arching position or keeping the swinging leg in a high bended position till the landing or in the opposite let the leg fall down right after takeoff or ask for a special arm support (leading arm, double arm swing or Fosbury-wise). From time to time I change the approach from “J”-curve to a half “C”-curve, which generates more inward leaning and more raising-up and rotating in the takeoff, so the flight is longer and the athletes over rotates. By this and other tasks I try to give the athletes a better orientation in the flight and an imagination of their abilities. So we find out the individual optimum in technique.

Beside the scissors and the flop from left and right side (leg) I use the flop bar clearance from a both leg jump. In former times I did this more from a standing position, nowadays I prefer to do it with a one or two step approach, so the contact time is shorter and the flight is longer. In preparation period I mix five techniques to a high jump pentathlon, in which a single athlete fights against him-/herself in the different techniques. They include 1. scissors from the normal jumping leg,, 2. scissors from the other leg, 3. frontal high jump (tuck jump). 4. Flop with the not jumping leg, 5. Flop with both legs from normal side. In average the athletes reach in all techniques the same heights. Before starting the pentathlon the athlete marks all approaches (5-6 steps). We start with a low height, so we can raise the bar 8-10 times. Then we do the jumping very fast, after one jump the athlete goes to the next mark and so on. After clearing the height in all five techniques, the coach increases the height, so the athlete can continue directly. After a miss-attempt in one technique, we will not repeat it, but give him/her a last chance on the next height. If he/she clears it, the athlete can continue also in this technique, after two following miss-attempts this technique is finished. In addition we come to 40—50 jumps in one session. Because of the short brakes the athletes come to sweat and do something for their jump endurance. At the end all best results will be added, f. e. to 7,00 m. In one preparation time I repeat this pentathlon two to three times.

If you work with athletes several years, you also can use even different techniques, for example the western roll. Similar to the scissors it is simple and does not depend so much on correct rotations. So the athletes understand it in one training session and then you can work with it for some weeks. The athletes will improve their results and love it. For sure I also like the straddle style, but it takes more time to teach it and the transfer to the flop is not that big.

In a normal high jump training after 10-12 jumps I give the athletes an active rest.

## Training practice: Various techniques and training regimes (Wolfgang Killing)

In the training demonstration I want to show several contents:

- small jumps and skip jumps warm-up and for coordination
- the methodical sequence learning the flop style in a few steps
- normal high jump training with coaches observing positions and corrections
- helping positions, supporting training means
- high jump pentathlon: one athlete with five different techniques
- Six ground patterns of jumping-/bounding training
- Active rest with floor acrobatics, stabilization and medicine ball throwing

(as far as we will come)