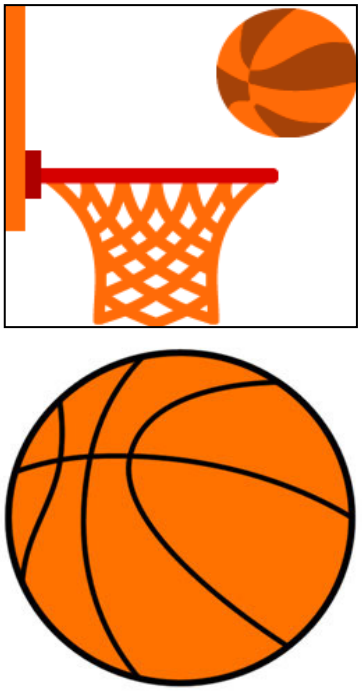
Jack and the Beanstalk



I. JACK'S PHYSIOLOGICAL RESPONSES

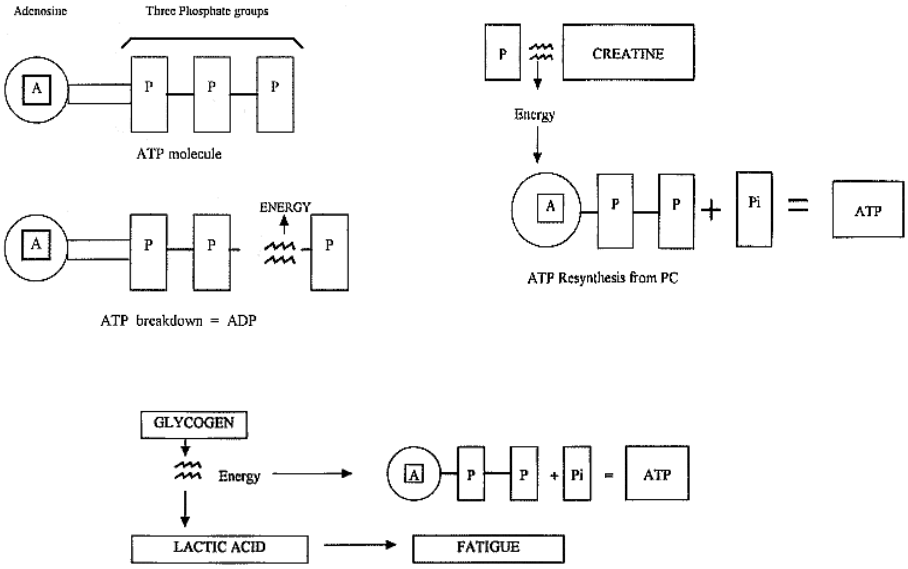
As point guard of his team, Jack's role was to push the ball upcourt and to start the offensive attack, as well as help direct the team. Thus he will be actively involved in the whole duration of both games. Let's see how his body reacted to his two games.

A. Game 1: Against the Average Team

As Jack's team was playing against a less fit team, he was able to perform at his own pace and not exhaust his energy systems. Jack's bursts of speed to jump or get into position required him to use his Adenosine Triphosphate-phosphocreatine (ATP-PC) system mainly. These short bursts of energy is provided by the breaking of high energy bonds between the last two phosphate groups of the ATP molecule found in mitochondria of cells. However this system is limited to 5-10 seconds, wherein the amount of CP molecules used for resynthesising ATP molecules have been depleted (Figures 1 and 2). Since Jack rarely used this system, he was able to easily replenish the phosphocreatines, which takes up to 2 minutes, and use this system again when exerting maximal effort.

The moderate intensity of the game favoured the use of the aerobic system, as well as the lactic acid system to a lesser extent. The lactic acid system involves the breakdown of glycogen in the absence of oxygen. While the breaking of bonds provides energy for resynthesising ATP, it also produces lactic acid, which can cause fatigue in skeletal muscle cells (Figure 3). The aerobic system relies on the combustion of glycogen (eventually fats and protein for longer durations) using oxygen to provide energy to resynthesise ATP (Figure 4). Thus Jack's ventilation rate rose and his heart rate increased to 106-118 bpm as his cardiovascular system worked more to provide oxygen to cells for combustion of glycogen and the breakdown of the lactic acid. These responses were accompanied with a rapid increase in stroke volume, consequently increasing cardiac output, too.

During and after the game Jack "wasn't tired" as the game did not exert him to meet his anaerobic threshold(AT) or lactate inflection point (LIP)- the point where lactic acid accumulates in the bloodstream, increasing the acidity in the blood and muscles. This means Jack was able to obtain enough oxygen to have a greater rate of removal of lactic acid, than its production. Therefore Jack avoided muscle fatigue, which explains the moderate heart rate and comfortable ventilation rate.

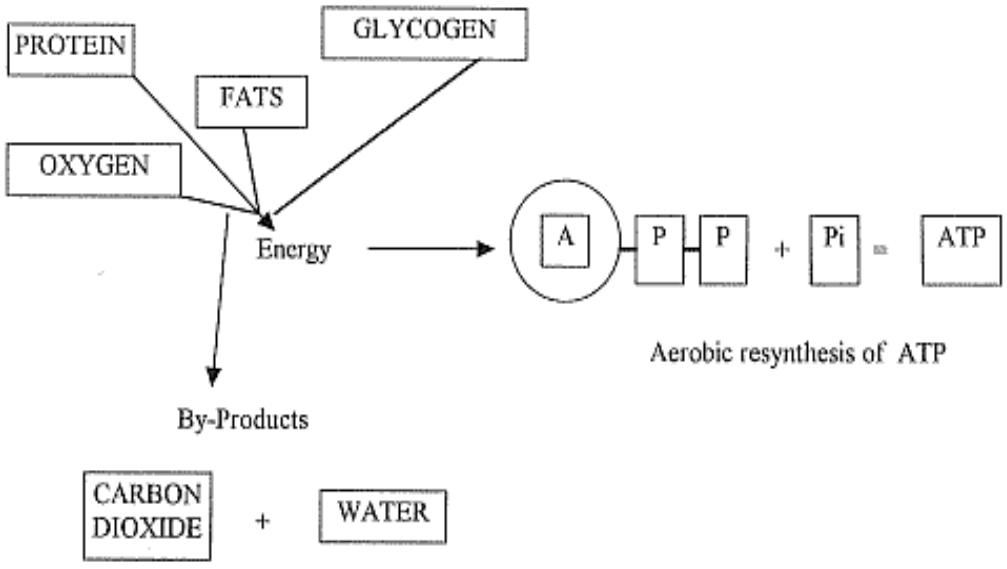


B. Game 2: Against the Elite Team

In this game, Jack was pushed to play at a significantly higher intensity and skill level than the last game. Thus his body found it harder to keep up with the demands of this round. Similar to the first game, ATP-CP system was initially the dominant energy system as it instantaneously provides energy. However the CP stores would have been quickly depleted in 10-15 seconds. Unlike the previous game, Jack was working with maximal effort for most of the game. This means the amount of CP molecules were not easily replenished as recovery of the system works best with rest. Therefore the ATP-CP system was quickly unavailable, thus Jack was forced to rely on his lactic acid (anaerobic glycolytic system) and the aerobic glycolytic system.

Jack's continuous rapid changing of directions, extra high jumps, bouts of running with minimal periods of rest, required an immediate source of energy. Thus the lactic acid system would have been the dominant system over the aerobic system. Jack's skeletal muscles constantly obtained energy by breaking down glycogen anaerobically, consequently producing lactic acid (Figure 3). Therefore the rate of production of lactic acid was very high. Lactate levels steadily rose in the bloodstream, particularly after reaching the anaerobic threshold, which would have been achieved from 60 to 70% of Jack's MHR, i.e. 122-143 bpm, as he is untrained.

Similar to the earlier round, the duration of the game accounted for the onset of the aerobic system (Figure 4). This, as well as the need to breakdown the lactic acid being produced, resulted in a significantly higher heart rate, greater than 79% of his MHR, and breathing rate, as the cardiovascular system works extra hard to meet the oxygen needs. Although Jack's stroke volume would have been only slightly higher or very close to his stroke volume in the previous game, as his heart would have reached its maximum capacity, his cardiac output was significantly greater due to his high heart rate. However, as Jack does not normally strain his cardiorespiratory and energy systems, he has a relatively low VO_2 max thus there was insufficient oxygen to match the rate of production of lactic acid and its rate of removal. The accumulation of lactic acid, more specifically hydrogen-ions, resulted in his fatigue and 'heavy' legs. Furthermore, the breaking down of glycogen and lactate produces heat, thus Jack was "sweating profusely" to counteract the increased heat.



II. JACK'S SIX-WEEK TRAINING PROGRAM

A. Background

Jack's main sporting past time has been golf. Golf often only involves short explosive movements; thus the ATP-CP system would be the predominant system, particularly during a golf drive, with copious amounts of time between each swing for the system to recover. This means Jack does not often strain the lactic acid system and the aerobic energy systems. Jack's resting heart rate was measured at 76 bpm - a relatively high heart rate, compared to the average resting heart rate of 70-73 bpm for men 15-25 years old. This suggests that, even at rest, his heart is working extra hard to supply oxygen to his cells.

B. Pre-training Preparation

Pre-screening

Although Jack is quite young and the health risks in starting a new training program is relatively low, it is beneficial to undergo a medical examination to identify any medical conditions, i.e. asthma,, that may result in injury and loss of motivation if not taken into consideration.

Goal

A valid training program should have a specific reasonable goal the athlete wants to reach. For Jack, this may be to increase his anaerobic threshold, wherein his lactic acid begins to accumulate and he gets fatigued at a higher percentage of his VO_2 max, or MHR (a cheaper and more practical measurement). This will allow him to meet the energy needs of a high-intensity basketball game.

Tips and Strategies

- **Partner** - a fitter partner can help Jack in various exercises, as well as, challenge him.
- **Heart rate monitor** - a simple monitor can assist Jack in determining if he is working past his anaerobic threshold and see any improvements in his fitness.
- **Record results** - each training day's results, i.e. heart rate reached, repetitions max (RM), should be recorded to establish his level of improvement.
- **Flexible program** - Jack's results and level of comfort during training should be considered throughout the program. If he feels the program is too intense or too easy, he may alter the program to suit his capability, maintain motivation and avoid injury.

C. Principles to Apply

Progressive Overload

To ensure fitness gains are made, Jack must gradually increase his training load throughout the program and adapt to it. This will be done in 3-week cycles:

- Build up fitness, with gradually increasing load (2 weeks)
- Active recovery, testing and adjustment of program (1 week)
- Build up fitness to a higher level, with gradually increasing load (2 weeks)
- Active recovery, testing and adjustment of program (1 week)

Specificity

Jack needs to train both his aerobic and anaerobic glycolytic systems to meet the demands of a high-intensity basketball game. The 6-week program will help improve strength endurance, which involves developing muscle strength and power (using resistance and plyometric training), aerobic capacity and the level of lactate threshold (using continuous, Fartlek, and interval training).

Reversibility

It is important to note that lack of training can significantly worsen Jack's level of fitness. Thus to continually improve and/or maintain his fitness level, Jack must continue regular training, even after the six-week program.

Variety

This principle is important in preventing boredom and overuse injuries. This will be done by interchanging the types of training - aerobic, strength and flexibility - during the week, and by using a variety of activities for each type of training,i.e. training the aerobic system by either running or cycling.

Training Thresholds

Jack will be training both his aerobic and anaerobic systems, therefore the training sessions require him to meet or exceed his anaerobic threshold of about 70-85% MHR (which is higher than the aerobic threshold). This ensures that Jack obtains some fitness gains.

FITT

Each training session is structured according to the FITT principle, which stands for frequency, intensity, time and type, making sure that quantity and quality are considered in each session to maximise results.

Warm-up/Cool-down

These are essential before and after each session.

The warm-up should at least include:

- 5-10 minutes of jogging or skipping to increase body temperature.
- 10-15 minutes of stretching (static, ballistic and PNF) beyond required range of motion.
- 10-15 minutes callisthenics, i.e. push-ups and sit-ups to increase blood flow to muscles.

The cool-down should consist of:

- 5-10 minutes of jogging or walking with decreasing intensity to return body temperature to normal.
- 5-10 minutes static stretching, particularly the muscle group used extensively, such as leg muscles.

D. Types of Training

Aerobic

In Jack's case, the more beneficial types include Fartlek and **interval** training. Although considered aerobic due to the duration of the activity, they both involve frequent bouts of maximal energy and speed, therefore developing the anaerobic system. The structure and intensity of these types of training are very similar to a short game of basketball, therefore improvements from this training can be applied directly to the sport.

Circuit

This type of training is best used for active recovery in weeks 3 and 6. It provides minimal improvements in aerobic capacity, therefore it is not as strenuous as other training sessions; yet it allows Jack to stay active and results in considerable gains in strength endurance, and flexibility. However, circuit training requires an ample amount of space and equipment, such as weights. If possible, this problem can be tackled by arranging circuit training sessions at school or in a leisure centre, or obtaining equipment to setup at home.

The following exercises require minimal equipment and should be performed in the following order:

1. Sit-ups
2. Step-ups
3. Press-ups
4. Squats
5. Shuttle Runs
6. Seated dips
7. Straddle Jumps
8. Bent Arm Pullovers

Resistance and Plyometric Training

Resistance training involves the use of increased load or weights to develop muscle strength, particularly essential stabilisers for running. These include muscles in the abdominal, back, and pelvic region. Sit-ups, back extensions, hip adduction/abduction are examples of exercise to strengthen the stabilisers. Running up hills is another form of resistance training.

Plyometrics are exercises in which the muscle is stretched before it is shortened, resulting in a forceful contraction. Therefore it is considerably beneficial for developing power, particularly in the arms and legs to avoid fatigue. These exercises include jump squats, clap push-ups, rebound jumping and medicine ball throwing.

As Jack develops absolute strength, he can then move on to increasing the exercise speed to develop power. Once he has built up an appropriate level of power, he should work on applying this over prolonged, repeated bouts, i.e. by increasing repetitions, to improve strength endurance. As a result, he will be more able to tolerate fatigue and the accumulation of lactic acid.

Flexibility

The three types of stretching - static, ballistic and PNF - are all incorporated in the warm-ups and cool-downs, and between exercises. This prevents injury and promotes hypertrophy.

E. Training Program

WEEK	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1							
2							
3							
4							
5							
6							

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