

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	30%	
2. Knowledge and Understanding Skills	40%	
3. Cognitive and Intellectual Skills	20%	
4. Practical Application Skills	0%	
5. Transferable Skills for Life and Professional Practice	10%	

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

University of Wales Trinity Saint David

BSc. Health, Nutrition and Lifestyle

BMSS5001 – Exercise Physiology

Assignment 1 (Physiological demands report)

The physiological demands of a 400m flat sprinter

Shericka Primus

Student ID #: 2114529

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E-Tutor: Geraint Forster

“The human body is an amazing machine” as it carries out various tasks such as breathing and seeing concurrently without consciousness and physiology helps us to understand how it all happens (Kenney, Wilmore and Costill, 2022). More specifically, exercise physiology is further concerned with not only how the body functions but how it reacts to stress factors from a single or repeated bout of exercise or physical activity (Smith, Ormsbee and Plowman, 2022). The body’s response to stimuli varies from individual to individual sometimes based on body composition, sex, and fitness (Castellani and Young, 2016) and similarly, the physiological demands are different between sports (Burkett, 2019). Burkett (2019) outlined that the physiological demands across sports vary based on the movements involved from running, jumping, throwing, swinging, swimming, and kicking as they all require different biomechanics and energy systems. This essay will be focused on sprint runners, particularly the 400m flat athletes. Before the 1900s a 400m event was classified as a mid-distance run, however, it has since changed to be considered an endurance sprint (Schiffer, 2008). Sprinting is said to be one of “the most dynamic and vigorous running technique” (Burkett, 2019). The 400m event is one of speed, power and endurance and the average running time for an elite athlete is 45 – 47 seconds with an average person running it between 70 to 120 seconds. It involves sagittal movement of the arms and leg and how long the athlete takes to run the distance is determined by their stride length and frequency. Sprinting has two major phases called the flight phase and the stance phase. Smith, Ormsbee and Plowman (2022) explained that the stance phase is the period that the foot is on the ground such as from the time the heel touches the ground up until the toe-off point. Once the leg leaves the ground, this is referred to as the flight stage. In comparison to long distance runners sprinters tend to spend more time in the air, swing their arms more briskly, and lift their knees higher (Smith, Ormsbee and Plowman, 2022). Additionally, when compared to mid-distance and long-distance runners they all have similar but varying physiological demands in energy metabolism, technique, and neuromuscular function.

For example, three energy systems work together to replenish ATP but sprinters predominantly use the anaerobic system when compared to long distance runners who rely heavily on the aerobic system (Nevill et al., 2008). The anaerobic system is said to generally be 65% dominant in 400m runners (Hanon, C. et al., 2010) and even 75% in elite athletes. Anaerobic metabolism includes the ATP-PC / alactic and Anaerobic glycolysis/ lactic acid

systems and the balance in the utilization of each cycle is determined by a person's VO₂ max ability to produce energy (Ghosh, 2004). As a sprinter exit his or her block, they are likely to use the ATP-CP system that is generally utilized for roughly 6-10 seconds of maximal effort (Smith, Plowman and Ormsbee, 2022). As acceleration occurs and more energy is needed the lactic acid system continues to make more ATP as the creatine phosphate stores in muscles are limited and is exhausted quickly (Schiffer, 2008). The lactic acid system creates these ATP by breaking down glucose and rebuilding the ADP (Smith, Plowman and Ormsbee, 2022). Smith, Plowman and Ormsbee (2022) went on to explain that the absence of oxygen causes the formation of pyruvic acid that is converted into lactic acid that accumulates in the body and causes muscular fatigue and interferes with muscular contraction. Thus, it is important to have a good overall metabolic energy system. If the aerobic system is not able to supply enough oxygen to muscles, the buildup of lactate acid can cause the muscle to become fatigued (Rønnestad and Mujika, 2013). Despite sprinting and the 400m flat is not seen as an endurance event, it is important for athletes to incorporate aerobic training into their training plan (Schiffer, 2008). Endurance training is said to improve mitochondria function that in return allows more production of ATP (Kenney, Wilmore and Costill, 2022). More ATP means more energy that allows an individual to train and compete longer. The 400m also creates a huge oxygen deficit and aerobic training will aid in the uptake of oxygen and reduce recovery time (Schiffer, 2008).

Sprinting involves a repeat of quick continuous eccentric and concentric movements and with the high demand for force, power, and speed in sprinting events, sprinters including those of the 400m distance recruit mainly type II / fast-twitch fiber muscles (Thompson, 2017). This is so because of their fast contraction ability and higher glycogen stores which makes them more ideal. Fast-twitch muscle fibers are generally relied on to increase high movement frequencies (Lievens, Stassen and Derave, 2021). Type IIa (fast-twitch oxidative) muscles are mainly preferred for a 400m sprint due to the endurance factor of the 400m event. This is because it can give explosive energy with and without the use of oxygen reducing the fatigue factor seen in type IIb muscles that are solely anaerobic and non-oxidative resulting in quicker buildup of lactate in the blood (Kenney, Wilmore, and Costill, 2022). Thus, it is suggested that training be done to convert fast-twitch type IIX fibers into type IIA fibers which are more fatigue resistant (Rønnestad, 2013). There are a lot of studies exploring the shift between muscle types and

Plotkin et al. (2021) suggest that intracellular signaling pathways may have a major part to play. Molecules such as the nuclear factor of activated T cells (NFAT), calcineurin and calcium dependent protein kinases are present in calcium-signaling pathways which are activated during muscle activation (Chin et al., 1998). Studies by McCullagh et al. (2004) and Serrano et al. (2001) have shown that the shift from type I to type II fibers is prevented if the NFAT pathway is blocked. The muscles that are highly activated and mostly discussed during sprinting requiring these fast-twitch fibers are usually those of the lower limb.

The muscle groups include hamstrings, calf muscles, quadriceps, glutes and hip flexors. An additional system used that is not widely researched with the 400m event is the fascial system which has been regarded as important as these muscles (Parisi, 2021). It may not produce as much force as muscles but it synchronizes and synergizes movement that is essential for power and speed. The fascia comprises of collagenous connective tissue that interpenetrates and surrounds joints, muscles, nerves, organs and vascular beds (Klinger et al., 2014). It is possible to strengthen fascia and connective tissue which can increase elasticity, enhance strength and movement and possibly reduce injuries such as pulls and strains. Many use plyometric movements to achieve this. Plyometric exercises allow a person to reach maximum force in a short period of time. Lum et al. (2019) explained that this is done utilizing the stretch-shortening cycle that involves a rapid stretch of a muscle followed by a rapid shortening of that same muscle. These may include jump squats, jump rope and clapping pushups. It is said to increase musculotendinous stiffness which is great for the transition from the stance to the flight stage as the elasticity provides more force and utilizes less energy (Lum et al., 2019). This elasticity improves stride length and reduces the shortening time (Kubo, Ishigaki and Toshihiro, 2017). Despite this elasticity being said to improve performance, caution should be taken as stiffness has been related to injuries in some studies and the amount of stiffness required for optimal performance is not defined (Struzik et al, 2021). Lorimer and Hume (2016) state that stiffness of the lower limb may be associated with Achilles tendon injury. However, they also expressed that other factors may contribute to this such as the sport itself and the repeated force requirements. One should avoid overloading while training to reduce the chance of damaging muscles and the fascia systems. It is also good to avoid exercises that promote too much hypertrophy as increased body mass may reduce speed and requires more force and power to carry one's body weight.

Despite muscles are associated with bigger force and explosion when hypertrophied, extra muscle mass requires greater effort and involves higher energy expenditure.

Apart from training to improve neuromuscular function and building power and strength, technique is also important in sprinting to allow more speed and preventing injury. When exiting the block an athlete should try to take off in at 45-degree angle (Parisi, 2021). This allows the utilization of maximal horizontal force and enough vertical force to keep the body from stumbling. As the athlete accelerates an upright torso should be kept using the core and triple extension to promote range of motion. When landing knees should be approximately 20 degrees bent to help absorb shock and reduce the moment of inertia. The knees should not be fully extended and sprinters should aim to land at the center of mass or not too far in front. Landing too far in front of the center of mass causes a ground force reaction that acts as a braking force that can cause a runner to slow down. Knees should also be flexed at a 90-degree angle and the ankles dorsiflexed to decrease the moment of inertia (Burkett, 2019). Sprinting requires flexibility in the hip and shoulders. The shoulders should be relaxed and the arms flexed at a 90 degree angle swinging powerfully backward and forward (Carr, 1999 and Burkett, 2019). This helps to give momentum and counterbalance the lower body movement and drive the athlete forward. Thus, the rotatory cuff muscles should be trained as well. Any form of tension whether from your face, neck, shoulders or hands should be avoided as these acts may result in compensatory measures that affect stride length and frequency (Carr, 1999 and Parisi, 2021). Sprinters in the past were known to clench their fists when running because they thought that tension increased force, however it restricts the movement of the arm and flexibility that is needed in the shoulders when sprinting (Carr, 1999).

Common injuries associated with sprinting are hamstring strains, achilles tendinopathy, and patellofemoral pain syndrome (Kakouris, Yener and Fong, 2021). Sugiura et al. (2022) stated that sprinters show the highest rates of hamstring strain incidences. Some causes range from weak hip flexors, insufficient hamstring strength, left to right muscle imbalance or relative strength to the quadricep strength ratio (Sugiura et al., 2022).. Heer et al. (2019) advised that the risk of reinjury can be reduced through the strengthening and stretching of hamstring tendons

using eccentric exercise. The hamstrings must produce powerful force and are prone to injury due to the role they play in knee flexion and hip extension. The risk of these injuries may be reduced with proper training and running techniques as aforementioned. Old injuries should also be assessed in whether performance is being affected by them through compensatory measures.

The physiological demand of each sport varies upon the mechanical movements involved and the intensity. 400mF runners will depend mainly on their anaerobic metabolic system when compared to mid and long distance runners but they must improve both aerobic and anaerobic systems to work efficiently. The force, power and strength required in a 400m sprint utilizes fast-twitch fibers and the muscles mainly worked are those of the lower limb including the hamstrings and calves. There are different views on the preference of type IIA fibers being more suited for 400m sprinters compared to those of the 100 and 200m but the training element will be left to the athlete and their trainers. The fascia system also plays an important role in coordinating these movements and should be taken into consideration while training. When training for strength and power both the lower and upper body should be trained with limited hypertrophy effects that may slow them down due to the additional muscle mass. All muscles should be trained equally to avoid injuries caused by imbalances to improve performance. Whereas power, speed and strength is most often associated with the 400m sprint, flexibility and technique is just as important. Sprinting techniques help to improve performance and aid in the prevention of some injuries.

Words: 2017

References

Burkett, B. (2019) *Applied sport mechanics*. Fourth edition. Champaign, IL: Human Kinetics.

Carr, G.A. (1999) *Fundamentals of track and field*. 2nd ed. Champaign, IL: Human Kinetics.

Castellani, J.W. and Young, A. J. (2016) 'Human physiological responses to cold exposure: Acute responses and acclimatization to prolonged exposure', *Autonomic Neuroscience*, 196, pp.63-74.

Chin, E.R. et al. (1998) 'Calcineurin-Dependent Transcriptional Pathway Controls Skeletal Muscle Fiber Type', *Genes Dev.*, 12, pp. 2499–2509.

Ghosh, A.K. (2004) 'Anaerobic threshold: its concept and role in endurance sport', *Malays J Med Sci*. 11(1), pp.24-36.

Hanon, C. and Gajer, B. (2009) 'Velocity and Stride Parameters of World-Class 400-Meter Athletes Compared with Less Experienced Runners', *J. Strength Cond. Res.*, 23, pp. 524–531.

Hanon, C. et al. (2010) 'Oxygen uptake and blood metabolic responses to a 400-m run', *European Journal of Applied Physiology*, 109 (2), pp.233- 240.

Heer, et al. (2019) 'Hamstring injuries: Risk factors, treatment, and rehabilitation', *JBJS*, 101(9), pp.843-853.

Kakouris, N., Yener, N., and Fong, D.T.P. (2021) 'A systematic review of running-related musculoskeletal injuries in runners', *Journal of sport and health science*, 10(5), pp.513–522.

Kenney, W.L., Wilmore, J.H. and Costill, D.L. (2022) *Physiology of sport and exercise*. Eighth edition. Champaign, IL: Human Kinetic.

Klingler, W. et al. (2014) 'Clinical relevance of fascial tissue and dysfunctions', *Current pain and headache reports*, 18(8), 439.

Kubo, K. Ishigaki, T. and Ikebukuro, T. (2017) 'Effects of plyometric and isometric training on muscle and tendon stiffness in vivo', *Physiol Rep*, 5(15):e13374.

Lievens, E., Stassen, F., and Derave, W. (2021). *Myotypes: the relevance of muscle fiber typology in sports*. Universiteit Gent.

Lorimer, A. V., & Hume, P. A. (2016) 'Stiffness as a Risk Factor for Achilles Tendon Injury in Running Athletes', *Sports medicine (Auckland, N.Z.)*, 46(12), pp.1921–1938.

Lum, D. et al. (2019) 'Effects of intermittent sprint and plyometric training on endurance running performance', *Journal of Sport and Health Science*, 8(5), pp. 471-477.

McCullagh, K.J.A., et al. (2004) 'NFAT Is a Nerve Activity Sensor in Skeletal Muscle and Controls Activity-Dependent Myosin Switching', *Proc. Natl. Acad. Sci. USA*, 101, pp.10590–10595.

Nevill, A.M. et al. (2008) 'The relative contributions of anaerobic and aerobic energy supply during track 100-, 400- and 800-m performance', *J. Sports Med. Phys. Fit*, 48, pp.138–142.

Parisi, B. (2021) *The anatomy of speed*. Champaign: Human Kinetics.

Plotkin, D.L, et al. (2021) 'Muscle Fiber Type Transitions with Exercise Training: Shifting Perspectives', *Sports (Basel)*, 9(9):127.

Rønnestad, B.R. and Mujika, I. (2013) ' Optimizing strength training for running and cycling endurance performance: a review', *Scandinavian Journal of Medicine & Science in Sports*, 24(4), pp.603-612.

Schiffer, J., (2008) 'The 400 metres. *New Studies in Athletics*', 23(2), pp.7-13.

Sedeaud, A. et al. (2014) 'BMI, a performance parameter for speed improvement', *PLoS One*, 9(2):e90183.

Serrano, A.L. (2001) Calcineurin Controls Nerve Activity-Dependent Specification of Slow Skeletal Muscle Fibers but Not Muscle Growth', *Proc. Natl. Acad. Sci. USA*, 98, pp.13108–13113.

Smith, D.L., Ormsbee, M.J. and Plowman, S.A. (2022) *Exercise physiology for health, fitness, and performance*. Sixth edition. Philadelphia: Lippincott Williams & Wilkins.

Sugiura, Y. et al. (2022) 'Strategic Prevention Program of Hamstring Injuries in Sprinters. Injury and Sports Medicine' [Working Title]. IntechOpen. DOI: 10.5772/intechopen.108075.

Thompson M. A. (2017) 'Physiological and Biomechanical Mechanisms of Distance Specific Human Running Performance', *Integrative and comparative biology*, 57(2), pp.293–300.