A Discussion on Muscle Structure and Muscle Building Exercises for Taekwon-Do.

This essay is submitted by Daniel Cossey as part of the requirements for ITF Taekwon-Do 2nd to 3rd Dan Black Belt Grading Syllabus. This essay discusses various aspects of the structure and function of muscles in relation to their use in Taekwon-Do (TKD). First, the general structure of muscle and how a contraction is generated will be explained, then the types of muscle fibres in relation to TKD training will be discussed, and finally, the usage of three different types of exercises for building muscle will be evaluated with a particular focus on concepts that should be utilized for strength training and muscle building specific for TKD. It should be noted that the exercises discussed in this essay are not for beginners and are more targeted towards the high-performance athlete.

Muscle Structure

Skeletal muscle is made up of bundles of long, thin, conjoint cells called muscle fibres. The part of the muscle that contracts and provides the force is called the sarcomere (see figure 1). Many sarcomeres are aligned next to each other to make long myofibrils (thin fibres) which are packed into the muscle fibre. The sarcomere is made of small filamentous molecules called actin and myosin. The way that contraction is generated using these actin and myosin molecules is called the sliding filament hypothesis. Actin is a thinner molecule that is suspended between molecules of thicker myosin at either end. Myosin has many heads protruding of it like golf club heads. When the muscle is activated (by your brain sending the signal for contraction- e.g. when you think to kick) and energy is added into the sarcomere, the myosin head structures can reach out and grab the actin. They then rotate backwards dragging the actin fibres in towards the centre of the myosin. This can happen until the actin and myosin are fully overlapping, with the actin molecules of each end touching in the centre. This shortens the sarcomere compared to before when the myosin molecules were only overlapping the actin at its ends. This happens in every sarcomere of a myofibril simultaneously so the whole myofibril shortens. Multiple myofibrils from multiple muscle fibres shorten at the same time and the whole muscle contracts. When the muscle is inactivated the myosin heads will stop dragging on the actin and the sarcomere will slide back to the longer resting position.

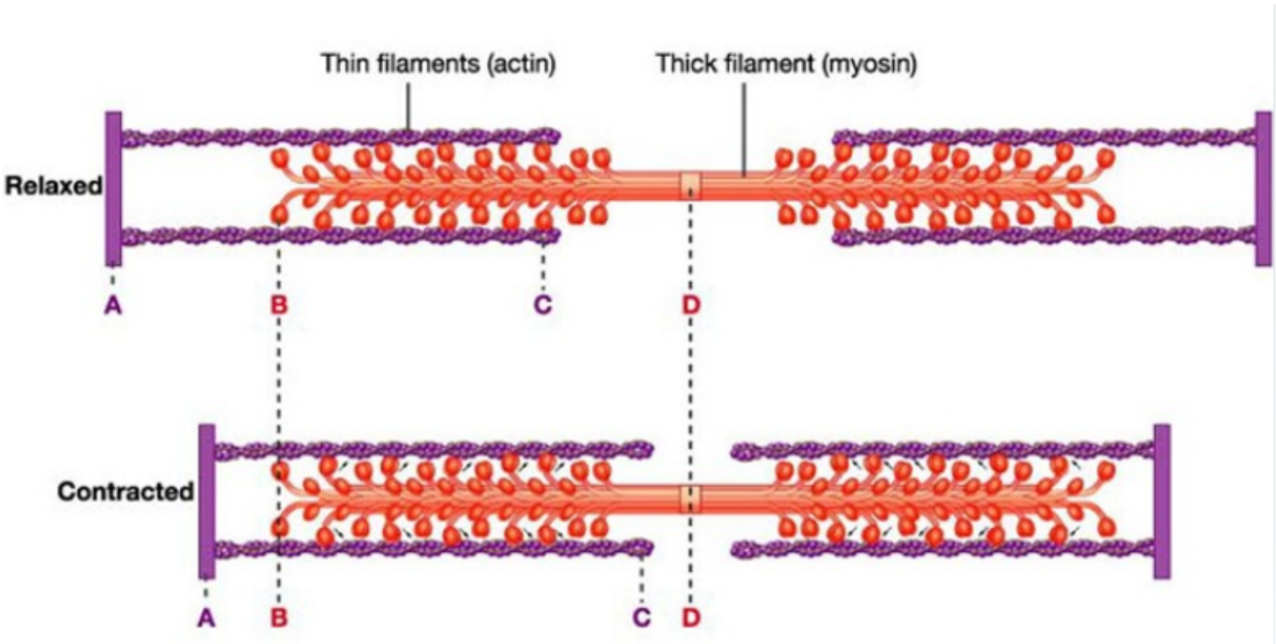

Figure 1. Diagram showing one part of the sarcomere in a relaxed and a contracted state. Note the myosin heads protruding from the myosin and that the distance between A and D shortens in the contracted state due to these heads pulling on the actin. You can also see that the size of the filaments does not change. The distance from A-C and B-D remains constant. Picture from: https://slideplayer.com/slide/10362930/

Muscles can only contract, so they only pull on bones rather than push. Thus, they are arranged in antagonistic pairs to achieve movement in both directions. For example, when you perform a turning kick the contraction of your quadricep muscles pulls on the knee joint and then the tibia, which causes the lower leg to be extended to the point of impact of the kick. When performing a reverse hooking kick the opposite muscles on the back of your leg, your hamstrings, contract and pull the opposite way on the lower leg causing the back heel to be pulled back in towards your glutes (this is a very simplistic view as other muscles should be used as well such as the core and glutes).

Types of Muscle

There are two main types of muscle, type I and type II. Type II can be further divided up into type IIA, B, and X. Type I fibres are slower, less easily fatigued and use oxygen to generate the energy to allow for the contraction. This generates more energy but is a slower process, thus these muscles are slower but longer lasting than the type II fibres. Type IIA can use either a non-oxygenic method or an oxygenic method, thus they are faster than type I, but not as fast as type IIB. Type IIB fibres are the fastest twitch fibres that produce energy quickly using non-oxygenic methods, so they can contract quickly. But this does not make so much energy so they runout of energy and fatigue quickly. Type IIX is an intermediate between IIA and IIB, and is found in humans, we do not have any IIB fibres. Type I fibres also need extra cellular organelles called mitochondria to generate the energy from oxygen, this means they have less room in the fibres for the contractile units, the sarcomeres, so they are not very powerful. On the other hand, type II fibres do not need these extra mitochondria as they don't need to use so much oxygen, so they have more room for sarcomeres, and thus can create more contracting power. So type I fibres are slow twitch fibres and don't generate much power but do not fatigue easily, whereas type II fibres are fast twitch (with the fastest being IIB, then IIX then IIA) which generate lots of power quickly but fatigue easily.

Humans have a mix of these different fibres in their muscle. Many scientists claim that the amount of type I compared to type II fibres you have is controlled genetically and there is no amount of training you can do to change this. This explains why you often see certain nationalities running crazy fast—they all have genetics that give them more type II fibres and less type I. From personal experience I find that I can last longer and do more jumps in special techniques than many others, without complaining that I have run out of jumping power or seeing a substantial drop in the height of the kick, whereas others start noting that they are fatiguing much earlier. On the other hand, despite a lot of plyometrics and explosive exercises my jump heights in my special techniques are not improving as much compared to many of the above-mentioned people. This suggests to me that they have more type II muscle fibres that generate more power and fatigue quickly, whereas I have more type I fibres that last longer but generate less power. This is not the best news considering that jump height is a key part of special techniques whereas repetitive jumping is not so important in special techniques. Despite the evidence that suggests that these fibre types do not change, some scientists debate this point and suggest that the evidence is not strong enough to reach this conclusion yet. Even if it is the case that you cannot change type I to type II fibres, your success or failure is not completely determined by genetics.

Getting Fast-Explosive Muscles

By the right training, you can change the type II muscle that you have from type IIA to type IIX, so you can get fibres that are faster twitch fibres, and therefore generate more power quickly. Due to the fast-explosive nature of TKD especially in disciplines like special techniques and power breaking, these are the kind of muscle fibres that are more beneficial. To change your type IIA to type IIX you would need to do fast explosive movements for short durations, or low repetition heavy (thus more power required) weights. For example, box jumps up to your maximum height for just a few reps and then letting your muscles recover, or heavy squats with low reps and long rests. You would not want to jump up onto a low box 15 times or do body weight squats for a hundred reps as this would require the longer lasting but less powerful type IIA muscles. This is why in special techniques training you should not do many attempts at a kick without sufficient rest. Your muscle will fatigue quickly as the muscles used for these fast-explosive movements are type IIX. Also if you are continuously training special technique with little rest and high reps then your body will build more IIA instead of IIX muscle, which will allow you to last longer without fatiguing but will not generate so much power. This is detrimental as we want to generate as much power as we can but only for approximately 5 jumps to do the best performance in competition, so we do not want to get longer lasting less powerful muscles. You should not assume that there is no point training, blaming genetically pre-determined ineffectiveness of your muscle, because with the right high intensity, fast, explosive, and powerful exercises coupled with sufficient rest, you can develop the muscle fibres that will maximise your explosive movements for TKD.

Types of Exercise

There are three commonly used classification for different exercises. These are concentric, eccentric, and isometric. **Concentric** movements involve muscle shortening to generate force. The mechanism of a concentric contraction is explained in the first paragraph. Concentric exercises are the most common, such as the upward portion of a bicep curl or the upward portion of a push up. In **isometric** exercises the muscle is contracting and producing force, but no movement is produced. As shown in figure 2 these contractions produce greater force than concentric contractions but less than eccentric contractions. An example of an isometric exercise is planking.

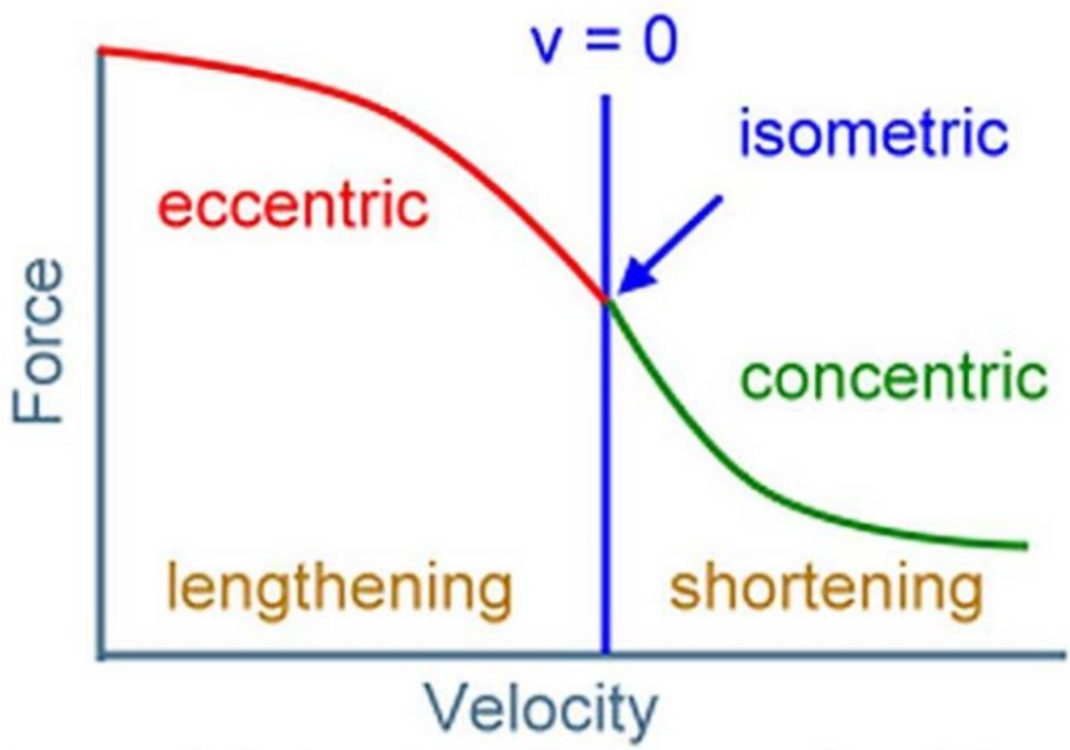

Figure 2. Graph showing the relationship of a muscle's force produced vs. the velocity it is moving at. When moving at negative velocity the muscle is lengthening, the contraction is eccentric and generating maximum force. This is only true to a point of maximum force after which the force will fall to zero.

Eccentric contractions involve lengthening of a muscle in response to a greater opposing force. They are called contractions as the muscle is attempting to contract but the opposing force is too great, so the force is lengthening the muscle. The myosin heads (as discussed in the first paragraphs) are reaching out and trying to pull on the actin filaments but the force trying to pull them apart is too great. So, despite the myosin heads working as fast as possible the filaments are pulled apart and the muscle lengthens. If this is done in a controlled way such that the opposing force on the muscle is only slightly greater than the force the muscle can generate, then the filaments will be pulled apart slowly and the muscle will be generating its maximum amount of force to try counteract this. As shown in figure 2 this force amount is much greater than that of concentric contractions.

This controlled lengthening of the muscles is the best way to grow more muscles. The fact that the current amount of myosin heads cannot generate enough pulling force on the actin filaments to cope with the force on the muscles, signals your body that you need more sarcomeres (more myosin and actin). Your body will build more muscle to be able to generate the force to counteract the extra force you keep putting on the muscles. An example of eccentric contraction exercises would be loading up extra weight on a weight belt such that you can no longer do a pull up. Then stepping up to the top of the bar and hanging off. You will slowly descend because even though your muscles are trying to generate the force to hold you up, they cannot hold the weight, so the sarcomeres are pulled apart and your muscle lengthens.

Eccentric exercises for Taekwon-Do

Eccentric exercises should be in-cooperated into TKD exercise programmes to build more TKD specific muscles. For example, to train the triceps for knifehand side strike you could lie on the ground with a weight slightly too heavy to hold at a near extension above your chest. Then let your hand and weight slowly lower toward your chest, using the other hand for safety. Similarly, for push ups and the muscles used in push ups, you could bench press with a weight that is too much to hold and will slowly force your arms down (with a spotter to lift the weight back up). This will help develop these muscles and be helpful for punching.

You could also do eccentric kicking exercises. For example, having a partner slowly push against an extended turning kick while you try to resist until the foot reaches back to the chambered position will eccentrically work the quads. Having a partner push against the rechambered reverse hooking kick until the leg is fully extended while you try to resist will eccentrically work the hamstrings. These two exercises could both be modified to the front kick position as well. Using a leg press machine with a weight slightly heavier than you can hold to slowly compress your legs in would also eccentrically work the quads, though appropriate safety mechanisms and a partner would be necessary for this.

Another option would be to use a flywheel inertia training device (FITD). This is a pully system on a wheel attached to a platform. The pully strap is unwound in the concentric part of the movement and then it rapidly winds up which allows your muscles to contract eccentrically. For example, as you stand up in a squat you unwind the strap and then it will rewind and pull down on you. You try to resist this force, but it pulls you down, creating a load of force greater than you can generate concentrically and so your muscle contracts eccentrically. This is a safe way to do eccentric squats, lunges, or other base exercises without needing spotters. It is possible that the FITD could be adapted for TKD kicking. If the FITD was fastened at hip height you could attach the end of the strap to the foot and perform a side kick with one hand on a wall for support. As you kick out (slowly) the strap will be unwound and then it will wind back up and cause your leg to be pushed back in towards your body, whilst you try to resist. You could also change the angle to perform front kick and turning kick. You could also preform punches with it. There are some possible issues with this idea though. The force generated from the kick/punch would be extremely high so it might not be possible to apply any resistance at all. Also, it might skew your technique due to the difficulties involved with absorbing the force horizontally on one leg. Unfortunately I was not able to get a hold of an FITD to test these ideas, but I suggest that these exercises are investigated further to determine if they are possible and if they should be incorporated into Taekwon-Do training.

Conclusion

One might be predisposed to reject various concepts discussed in this essay due to traditional ideas about Taekwon-Do training. Though traditional practices can be extremely beneficial, Taekwon-Do has always self-identified as "the scientific use of the body in the method of self-defence; aiming to gain ultimate use of one's body through intensive physical and mental training."[1] Science is always developing, and Taekwon-Do training should develop along with it. That is not to say that the exercises and concepts put forward in this essay are all certainly correct and unchangeable, as new research might suggest different results, but Taekwon-Do training should always be ready to adapt to the current scientific research and thus keep its status as a scientifically based martial art.

[1] General Choi Hong Hi, The Encyclopaedia of Taekwon-Do, Volume 1, Fifth Edition, 1999, P.15.