This study is inspired by the triathlon problem; triathletes presumably have a hard time to excel in all three disciplines that comprise triathlon. Herzog suggests that one reason is that a number of important force producing muscles are active at vastly different muscle lengths and muscle contraction speeds when comparing running and cycling\(^1\). The strength of a muscle is highly dependent on its instantaneous length and contraction speed. Moreover, Herzog claims that elite runners tend to be strong at long \textit{rectus femoris} lengths while elite cyclists tend to be strong at short \textit{rectus femoris} lengths. If this difference is genetic or due to training induced muscle adaption is not entirely clear. But there are studies of triathletes that suggest that some intrinsic muscle properties do adapt to training\(^2\). It seems that an athlete may alter the optimal muscle length for maximal force production by exercising the muscle at the preferred length (i.e., by training sport specific).

There are some anecdotal evidence that cross-country skiers who start to bicycle as summer training quickly fall in the ski rankings. If this is because of natural regression due to age or if it might be something similar to the triathlon problem is unknown. To bring some light on the issue, if cross-country skiers should bicycle for summer training, I carried out a simulation study.

Two musculoskeletal simulation models were created, one SKI model and one BIKE model, using the AnyBody Modeling System\textsuperscript{TM}4.1. AnyBody uses non-classical inverse dynamics and static optimization to solve the load distribution problem and compute the muscle forces from any given movement. The SKI model use boundary conditions (traditional style double-poling) from Holmberg and Lund\(^3\) and Holmberg et al.\(^4\) while the BIKE model use boundary conditions (cadence 140 rpm, average mechanical output 230 W) from Herzog and Vogt et al.\(^5\). Both simulation models have exactly the same body model; it is only the movement and external forces that differ.

Results show that several important leg muscles are active at different lengths and have different contraction speeds when comparing cross-country skiing (double-poling) and cycling, e.g. \textit{vastus lateralis} (Fig. 1). This muscle needs to produce around 300 N during part of the cycle in both models. In the SKI model, \textit{vastus lateralis} works only on the ascending part of the force-length curve and has very little lengthening or shortening. In the BIKE model, \textit{vastus lateralis} works mainly on the descending part of the force-length curve and has considerable lengthening and shortening speed. This indicates that skiers probably should avoid bicycling and instead roller ski during the summer.

Figure 1: Muscle length (a) and muscle contraction speed (b) of \textit{vastus lateralis} for SKI and BIKE models during one complete cycle. Optimal muscle length is 0.084 m. Negative muscle contraction speed corresponds to muscle shortening.