Influence of the contraction mode on the tendon structure: *rat model*

Kaux JF[1], Drion P[2], Besançon B[1], Libertiaux V[3], Croisier JL[1], Forthomme B[1], Colige A[4], Le Goff C[5], Franzen R[6], Defraigne JO[7], Cescotto S[3], Rickert M[8], Crielaard JM[1]

1. Physical Medicine Service, Department of Motility Sciences, University Hospital of Liège, University of Liège, Belgium. – jfkaux@chu.ulg..ac.be
2. Animal Facility of University Hospital of Liège, ULg-GIGA-R, University of Liège, Belgium.
3. Department Argenco, University of Liège, Belgium.
4. Laboratory of Connective Tissues Biology, GIGA-R, University of Liège, Belgium.
5. Department of Clinical Biology, University Hospital of Liège, University of Liège, Belgium.
6. Department of Biomedical and Preclinic Sciences, GIGA-R, University of Liège, Belgium.
7. CREDEC, Laboratory of Experimental Surgery, University of Liège, Belgium.
8. Department of Orthopaedic Surgery, University of Heidelberg, Germany.

1. Introduction:

Tendinopathies are common in sport and affect both upper and lower limbs. **Eccentric** rehabilitation is a successful way of treating them and now is becoming the "gold treatment". Although clinical results are very favorable, beneficial morphological and histological effects have not yet been elucidated. The aim of our experiment was to determine if any intrinsic modifications exist in a tendon trained in concentric or eccentric modes, in a **rat** model.

2. Methods*:

18 rats were divided into 3 groups: 6 for the control group, without physical restraint; 12 for a training of 1 hour, 3 times a week, for 5 weeks, at a speed of 17m/min (1km/h), on a inclined treadmill (Fig. 1): 6 rats running **uphill** at +15° for the **concentric** effort (group C) and 6 rats running **downhill** at -15° for the **eccentric** effort (group E). After this training period, the tricipital, patellar and Achilles tendons (Fig. 2-4) of both limbs were surgically removed in all 18 rats (Fig. 5). Tendons from five rats of each group were subjected to a **tensile test up to rupture** using a "cryo" jaw (Fig. 6-7). Tendons of the remaining rat of each group were subjected to a **histological** study [hematoxylin-eosin (HE) (Fig. 8-10); Masson's trichrome (MT)(Fig. 11-13)].


Fig. 1: 6 rats in the treadmill


Fig. 2: tricipital sample


Fig. 3: patellar sample


Fig. 4: Achilles sample

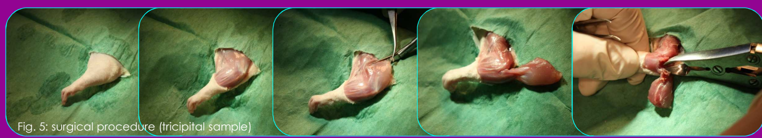
Fig. 5: surgical procedure (tricipital sample)

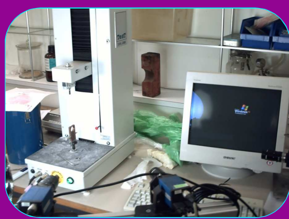
Fig. 6: traction machine, PC and tangentiel camera system

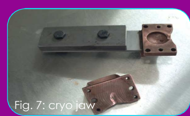
Fig. 7: cryo jaw


Fig. 15: lower limb (C)


Fig. 14: lower limb (control)

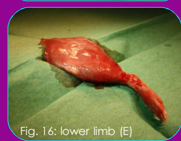
Fig. 16: lower limb (E)

Table 1 / Tendons	Groups	F (N)	S (mm²)	F/m (N/100g)	Constraints (Mpa)
Tricipital	Control	28.6	45.5	6.8	0.8
	C	36.5	74.8	8.3	0.5
	E	**49.4 (*)**	**79.1 (*)**	**10.5 (*)**	0.6
Patellar	Control	61.2	48.5	14.5	1.4
	C	71.3	36.8	16.1	2.9
	E	**79.3 (*)**	36.6	17.1	2.7
Achilles	Control	61.6	42.2	14.5	2.4
	C	66.4	32.6	15.0	3.6
	E	71.5	25.7	15.4	3.4

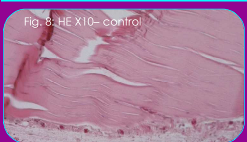
Fig. 8: HE X10– control


Fig. 9: HE X10 - C


Fig. 10: HE X10 - E

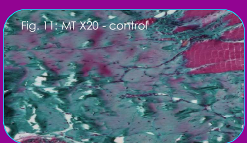
Fig. 11: MT X20 - control

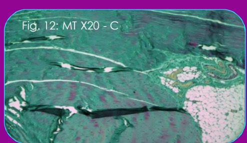
Fig. 12: MT X20 - C

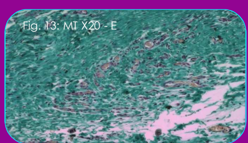
Fig. 13: MT X20 - E

3. Results:

Rats of **group E** had **more developed muscles** than in the 2 other groups (Fig. 14-16).

The biomechanical results (Table 1) showed **significant (*) changes** in **group E** only: (1) an increase of the force (F) required to rupture the tricipital (p=0.018) and patellar (p=0.047) tendons; (2) an increase of the surface area of the section (S) of the tricipital tendon (p=0.008); (3) an improvement of the ratio between the force necessary to rupture the tricipital tendon and the body mass (F/m) of the rats (p=0.043).

No significant change was observed as far as constraint (F/S) was concerned between groups.

Histologically (Fig. 8-13), tendons of **group E** presented, more peripheral blood vessels and a greater proportion of collagen.

4. Conclusion:

This study showed that the mechanical properties of tendon tissue are enhanced by eccentric training. Tendons become **stronger**, the amount of **collagen** increases and there is probably more interaction between collagen fibers (**mechanotransduction**). More studies with more samples are needed to confirm these findings.

5. References:

-Khan K.M. and Scott A., Mechanotherapy: how physical therapists' prescription of exercise promotes tissue repair. Br J Sports Med, 2009. 43(4):247-52.

-Wieloch P, Buchmann G, Roth W, Rickert M., A cryo-jaw designed for in vitro tensile testing of the healing Achilles tendons in rats. J Biomech. 2004 Nov;37(11):1719-22.

*All experimental procedures and protocols used in this investigation were reviewed and approved by the Institutional Animal Care and Use Committee of the University of Liège.