



Corrigendum: Myofibre Hypertrophy in the Absence of Changes to Satellite Cell Content Following Concurrent Exercise Training in Young Healthy Men

Baubak Shamim, Donny M. Camera and Jamie Whitfield*

Exercise and Nutrition Research Programme, Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, VIC, Australia

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A Corrigendum on

Myofibre Hypertrophy in the Absence of Changes to Satellite Cell Content Following Concurrent Exercise Training in Young Healthy Men

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In the original article, there was an error. The introduction incorrectly stated that work by Lundberg et al., 2013, 2014, de Souza et al., 2013, and Kazior et al., 2016 demonstrated reduced lean mass gains in the concurrent (resistance plus endurance) exercise trained group compared to resistance alone. This has been amended below. These papers were discussed in the correct context throughout the rest of the manuscript.

A correction has been made to *Introduction*, *Paragraph 1*:

Combining resistance- and endurance-based exercise training, or 'concurrent exercise training,' has previously been shown to impair strength and power adaptations compared to resistance training undertaken in isolation (Hickson, 1980; Craig et al., 1991; Hennessy and Watson, 1994; Kraemer et al., 1995; Dolezal and Potteiger, 1998; Bell et al., 2000; Häkkinen et al., 2003; Mikkola et al., 2012; Fyfe et al., 2016, 2018) and is referred to as the 'interference effect.' Notably, the result of concurrent exercise training on 'interferences' to lean mass gains relative to resistance training alone appear equivocal, with some studies showing greater gains in lean mass compared to resistance training alone (Kraemer et al., 1995; Bell et al., 2000; Rønnestad et al., 2012; Lundberg et al., 2013, 2014; Tomiya et al., 2017; Fyfe et al., 2018), while others have observed comparable (de Souza et al., 2013) or smaller gains in lean mass compared to resistance training alone (Sale et al., 1990; Timmons et al., 2018; Spiliopoulou et al., 2019). As such, understanding the ability of skeletal muscle to simultaneously adapt to divergent training stimuli is a topic that has received considerable attention (Nader, 2006; Wilson et al., 2012; Hamilton and Philp, 2013; Baar, 2014; Fyfe et al., 2014; Perez-Schindler et al., 2015; Murach and Bagley, 2016; Varela-Sanz et al., 2016; Coffey and Hawley, 2017; Doma et al., 2017; Berryman et al., 2018; Eddens et al., 2018; Fyfe and Loenneke, 2018; Hughes et al., 2018). Though the underlying cause of discrepancies in the degree of muscle hypertrophy achieved with concurrent versus resistance training remains unclear, it has recently been proposed that the potential for myofibre hypertrophy in response to chronic concurrent exercise training may be limited by satellite cell content (Babcock et al., 2012).

The authors apologize for this error and state that this does not change the scientific conclusions of the article in any way. The original article has been updated.

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> *Correspondence: Jamie Whitfield Jamie.Whitfield@acu.edu.au

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REFERENCES

- Baar, K. (2014). Using Molecular Biology to Maximize Concurrent Training. Sports Med Auckl Nz 44, 117–125. doi: 10.1007/s40279-014-0252-0
- Babcock, L., Escano, M., D'Lugos, A., Todd, K., Murach, K., and Luden, N. (2012). Concurrent aerobic exercise interferes with the satellite cell response to acute resistance exercise. AJP Regul Integr Comp Physiol 302, R1458–R1465.
- Bell, G. J., Syrotuik, D., Martin, T. P., Burnham, R., and Quinney, H. A. (2000). Effect of concurrent strength and endurance training on skeletal muscle properties and hormone concentrations in humans. *Eur J Appl Physiol* 81, 418–427. doi: 10.1007/s004210050063
- Berryman, N., Mujika, I., and Bosquet, L. (2018). Concurrent Training for Sports Performance: The Two Sides of the Medal. *Int J Sports Physiol Perform*. 14, 1–22.
- Coffey, V. G., and Hawley, J. A. (2017). Concurrent exercise training: do opposites distract? J Physiol 595, 2883–2896. doi: 10.1113/jp272270
- Craig, B. W., Lucas, J., Pohlman, R., and Stelling, H. (1991). The Effects of Running, Weightlifting and a Combination of Both on Growth Hormone Release. J Strength Cond Res. 5, 198–203. doi: 10.1519/00124278-199111000-00005
- de Souza, E. O., Tricoli, V., Roschel, H., Brum, P. C., Bacurau, A. V. N., Ferreira, J. C. B., et al. (2013). Molecular adaptations to concurrent training. *Int J Sports Med* 34, 207–213.
- Dolezal, B. A., and Potteiger, J. A. (1998). Concurrent resistance and endurance training influence basal metabolic rate in nondieting individuals. *J Appl Physiol* 85, 695–700. doi: 10.1152/jappl.1998.85.2.695
- Doma, K., Deakin, G. B., and Bentley, D. J. (2017). Implications of Impaired Endurance Performance following Single Bouts of Resistance Training: An Alternate Concurrent Training Perspective. Sports Med. 47, 2187–2200. doi: 10.1007/s40279-017-0758-3
- Eddens, L., van Someren, K., and Howatson, G. (2018). The Role of Intra-Session Exercise Sequence in the Interference Effect: A Systematic Review with Meta-Analysis. Sports Med Auckl NZ 48, 177–188. doi: 10.1007/s40279-017-0784-1
- Fyfe, J. J., Bartlett, J. D., Hanson, E. D., Stepto, N. K., and Bishop, D. J. (2016). Endurance Training Intensity Does Not Mediate Interference to Maximal Lower-Body Strength Gain during Short-Term Concurrent Training. *Front. Physiol* 7:487.
- Fyfe, J. J., Bishop, D. J., Bartlett, J. D., Hanson, E. D., Anderson, M. J., Garnham, A. P., et al. (2018). Enhanced skeletal muscle ribosome biogenesis, yet attenuated mTORC1 and ribosome biogenesis-related signalling, following short-term concurrent versus single-mode resistance training. *Sci Rep* 8, 560.
- Fyfe, J. J., Bishop, D. J., and Stepto, N. K. (2014). Interference between Concurrent Resistance and Endurance Exercise: Molecular Bases and the Role of Individual Training Variables. Sports Med 44, 743–762. doi: 10.1007/s40279-014-0162-1
- Fyfe, J. J., and Loenneke, J. P. (2018). Interpreting Adaptation to Concurrent Compared with Single-Mode Exercise Training: Some Methodological Considerations. Sports Med 48, 289–297. doi: 10.1007/s40279-017-0812-1
- Häkkinen, K., Alen, M., Kraemer, W. J., Gorostiaga, E., Izquierdo, M., Rusko, H., et al. (2003). Neuromuscular adaptations during concurrent strength and endurance training versus strength training. *Eur J Appl Physiol* 89, 42–52. doi: 10.1007/s00421-002-0751-9
- Hamilton, D. L., and Philp, A. (2013). Can AMPK mediated suppression of mTORC1 explain the concurrent training effect? *Cell Mol Exerc Physiol* 2, e4.
- Hennessy, L. C., and Watson, A. W. S. (1994). The Interference Effects of Training for Strength and Endurance Simultaneously. J Strength Cond Res 8, 12. doi: 10.1519/00124278-199402000-00003
- Hickson, R. C. (1980). Interference of strength development by simultaneously training for strength and endurance. *Eur J Appl Physiol* 45, 255–263. doi: 10.1007/bf00421333
- Hughes, D. C., Ellefsen, S., and Baar, K. (2018). Adaptations to Endurance and Strength Training. *Cold Spring Harb Perspect Med* 8, a029769.
- Kazior, Z., Willis, S. J., Moberg, M., Apró, W., Calbet, J. A. L., Holmberg, H.-C., et al. (2016). Endurance Exercise Enhances the Effect of Strength Training on Muscle Fiber Size and Protein Expression of Akt and mTOR. *PLoS One* 11:e0149082. doi: 10.1371/journal.pone.0149082

- Kraemer, W. J., Patton, J. F., Gordon, S. E., Harman, E. A., Deschenes, M. R., Reynolds, K., et al. (1995). Compatibility of high-intensity strength and endurance training on hormonal and skeletal muscle adaptations. *J Appl Physiol*. 78, 976–989. doi: 10.1152/jappl.1995.78.3.976
- Lundberg, T. R., Fernandez-Gonzalo, R., Gustafsson, T., and Tesch, P. A. (2013). Aerobic exercise does not compromise muscle hypertrophy response to short-term resistance training. *J Appl Physiol* 114, 81–89. doi: 10.1152/japplphysiol.01013.2012
- Lundberg, T. R., Fernandez-Gonzalo, R., and Tesch, P. A. (2014). Exerciseinduced AMPK activation does not interfere with muscle hypertrophy in response to resistance training in men. J Appl Physiol 116, 611–620. doi: 10.1152/japplphysiol.01082.2013
- Mikkola, J., Rusko, H., Izquierdo, M., Gorostiaga, E., and Häkkinen, K. (2012). Neuromuscular and Cardiovascular Adaptations During Concurrent Strength and Endurance Training in Untrained Men. *Int J Sports Med* 33, 702–710. doi: 10.1055/s-0031-1295475
- Murach, K. A., and Bagley, J. R. (2016). Skeletal Muscle Hypertrophy with Concurrent Exercise Training: Contrary Evidence for an Interference Effect. *Sports Med Auckl NZ* 46, 1029–1039. doi: 10.1007/s40279-016-0496-y
- Nader, G. A. (2006). Concurrent strength and endurance training: from molecules to man. *Med Sci Sports Exerc* 38, 1965–1970. doi: 10.1249/01.mss.0000233795.39282.33
- Perez-Schindler, J., Hamilton, D. L., Moore, D. R., Baar, K., and Philp, A. (2015). Nutritional strategies to support concurrent training. *Eur J Sport Sci* 15, 41–52. doi: 10.1080/17461391.2014.950345
- Rønnestad, B. R., Hansen, E. A., and Raastad, T. (2012). High volume of endurance training impairs adaptations to 12 weeks of strength training in well-trained endurance athletes. *Eur J Appl Physiol* 112, 1457–1466. doi: 10.1007/s00421-011-2112-z
- Sale, D. G., Jacobs, I., MacDougall, J. D., and Garner, S. (1990). Comparison of two regimens of concurrent strength and endurance training. *Med Sci Sports Exerc* 22, 348–356.
- Spiliopoulou, P., Zaras, N., Methenitis, S., Papadimas, G., Papadopoulos, C., Bogdanis, G. C., et al. (2019). Effect of Concurrent Power Training and High-Intensity Interval Cycling on Muscle Morphology and Performance. J Strength Cond Res doi: 10.1519/JSC.000000000003172 Online ahead of print,
- Timmons, J. F., Minnock, D., Hone, M., Cogan, K. E., Murphy, J. C., and Egan, B. (2018). Comparison of time-matched aerobic, resistance, or concurrent exercise training in older adults. *Scand J Med Sci Sports* 28, 2272–2283. doi: 10.1111/sms.13254
- Tomiya, S., Kikuchi, N., and Nakazato, K. (2017). Moderate Intensity Cycling Exercise after Upper Extremity Resistance Training Interferes Response to Muscle Hypertrophy but Not Strength Gains. J Sports Sci Med 16, 391–395.
- Varela-Sanz, A., Tuimil, J. L., Abreu, L., and Boullosa, D. A. (2016). Does concurrent training intensity distribution matter? J Strength Cond Res Natl Strength Cond Assoc. 31, 181–195. doi: 10.1519/JSC.000000000001474
- Wilson, J. M., Marin, P. J., Rhea, M. R., Wilson, S. M. C., Loenneke, J. P., and Anderson, J. C. (2012). Concurrent training: a meta-analysis examining interference of aerobic and resistance exercises. J Strength Cond Res Natl Strength Cond Assoc 26, 2293–2307. doi: 10.1519/jsc.0b013e31823a3e2d

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