

Reply

Reply to Ruby, B. Comment on Collins, C.N., et al. Body Composition Changes of United States Smokejumpers during the 2017 Fire Season. *Fire* 2018, 1, 48. *Fire* 2019, 2, 15

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Ruby [1] helped identify minor text mistakes or areas for clarification that occurred in Collins et al. [2]. The text mistakes in the article do not affect the study results and in each case help to strengthen clarity of the study methods and validity of the results. For this, Dr. Ruby is thanked for his evaluation.

In the final paragraph of Collins et al. [2], the reference to Butler et al. [3] is incorrect, as indicated by Ruby [1]. The correct reference is the report of wildland firefighter (WLFF) fatalities from 2007–2016 by the National Wildland Coordinating Group (NWCG) [4], which supports statements in Collins et al. [2] that cardiac arrest was the leading cause of WLFF fatalities between 2007 and 2016 (24%). Over this period, vehicle accidents constituted 20% and aircraft constituted 18% of fatalities. We agree that the latter two categories were greater between 1990 and 2006, and when the two categories are combined for the 2007–2016 period.

The skinfold measurement protocol presented in the Materials and Methods Section left out a methodological detail of skinfold caliper measurements. Measurements reported in the study were the mean of three, replicated absolute measurements of chest, abdomen, and thigh. This was incorrectly reported as tricep, abdomen, and thigh. As published, the methods indicated that individual measurements were repeated if they differed by more than 2 mm, which is consistent with American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription [5]. However, no measurements within the current study varied by more than 2 mm, and no measurements were repeated for this reason. A simple correction to the original paper is hereby submitted removing the following sentence: “All repeated measurements were required to be within 2 mm of each other or re-measured.” This sentence should be replaced with the following: “The mean of the three measurements was used for analysis which consisted of three replicated absolute measurements of the chest, abdomen, and thigh.” This correction results in clarified methods that are more conservative than those originally described.

A text edit made in the last paragraph of the Discussion section during the final round of peer review revisions apparently introduced confusion based on commentary in Ruby [1]. The phrase “In conclusion” was added to the first sentence to improve the flow of text. That introduced confusion that subsequent sentences were considered additional conclusions, even though the following sentence clearly identified a study limitation. With publication of this response, a correction is issued, moving the sentence as written to the end of the paragraph in order to clarify its intended meaning.

Below are responses to specific points presented by Ruby [1]:

Specific Comments

1. Ruby [1] comments on the skinfold methodology error estimate of $\pm 3.5\%$. As mentioned in Collins et al. [2], the Lange Skinfold calipers have an assumed measurement error of $\pm 3.5\%$ largely due to (1) participant’s hydration status, (2) whether or not their body is inflamed

- (i.e., after a workout or other physical activity), and (3) the researcher's level of experience completing skinfold testing [5]. The Lange Skinfold Calipers have been used in research studies for decades [6]. To address factors that may increase skinfold error based on [5], Collins et al. [2] instructed participants to be adequately hydrated, and body fat (BF) percentage testing was performed at the same time and location prior to any physical activity by the same single observer, who is a certified American Council on Exercise (ACE) and National Strength and Conditioning Association and Certified Strength and Conditioning Specialist (NSCA-CSCS) trainer with over 13 years of prior experience. Lange Skinfold Calipers are calibrated at the factory with no further calibration needed [7]. However, to ensure accurate measurements, the calibration performed at the factory was examined prior to BF testing by a series of tests that evaluate the distance and pressure between the jaws of the caliper [8]. Lange Skinfold calipers intra-observer and inter-observer errors are low compared to between-subject variability [9], and error is minimized by having the same person perform the test [10]. This, coupled with the very homogenous population and a very low observed standard error in the raw data measurements ranging from 0.0–0.9 for all nine subjects support the findings of Collins et al. [2].
2. To further strengthen these findings there are various methods to correct for the additive properties of Type I error probabilities [11–14], but there is a lack of consensus as to whether, or which, is best. While Bonferroni is widely used for multiple tests, it is also known to be too conservative [15]. For Collins et al. data [2], a better alternative was Hotelling's T^2 which is a multivariate test for related observations on a single group of individuals [16] to simultaneously test for differences in body weight (measured in kilograms) and BF (measured in percent) over the course of the firefighting season. The results of Hotelling's test with the data suggest that either body fat or body weight or both were significantly different at $\alpha = 0.1$ for a two-tailed hypothesis test compared to the null hypotheses that no differences exist in either variable. Subsequent to the significant result of the omnibus multivariate analysis of variance (MANOVA), the results of the individual comparisons for body fat and body weight are identical to the results reported in Collins et al. [2]. Thus, we maintain that the results, showing that only BF increased ($\alpha = 0.05$) over the course of the season, are correct and also quite conservative since we tested the null hypotheses that both BF and body weight either did not change or decreased over the course of the season with a one-tailed test and with the omnibus MANOVA.
 3. *"The authors outline a misconception of what body composition analyses may provide agencies and fire crews in relation to detecting underlying cardiovascular risk."* Ruby's [1] statements are not necessarily informed by current research on the importance of skinfold measurements as indicators of health status or on the importance of cardiovascular health for WLFF. Recent results from a large study ($n = 870$) of seemingly healthy white males showed that skinfold thickness is an independent predictor of all-cause mortality over 27.7 years of follow-up [17]. Cardiovascular disease (CVD) is the leading cause of on-duty firefighter fatalities¹ (see, e.g., Li et al. [18] for several recent references). Metabolic syndrome components (MetS) are common measures of cardiac health and occurs in approximately 10% of firefighters (not specifically WLFF) [8] as well as athletes [19]. Body fat percentage determined using hydrostatic weighing and skinfold measurements is positively associated with MetS in both male and female firefighters after controlling for age group, smoking, and alcohol ($n = 947$ males; 76 females) [8]. Because of the recent linkages among skinfold-derived body composition metrics and mortality in longitudinal studies [17], and between MetS and skinfold-derived body composition metrics among firefighters specifically, and the fact that heart attacks were the most common cause of fatalities among WLFF from 2007–2016 [4], federal agencies in charge of WLFF health are encouraged to review and consider scientific results from a range of sources and use a variety of research methods to evaluate related hypotheses.

¹ Firefighters defined broadly (i.e., not limited to WLFF) [8].

4. “Since fat free mass is also inclusive of total body water, even subtle variations can increase the measurement errors associated with the skinfold technique.” [1]. Ruby [1] does not recognize recent literature showing that the effects of hydration status are most relevant when three and four compartment models that include total body water are used [20], and are less important with two compartment models as was used in Collins et al. [2]. Furthermore, although hydration may affect skinfold thickness, it does not affect skin compressibility in healthy males at up to 2.11% body weight change [21]. Additionally, the Jackson and Pollock three-site body density equations [22] and the Siri body density to body fat equation [23], were developed specifically for this population and the Jackson–Pollock equation has been validated as giving estimates not significantly different from underwater weighing [24].
5. “It is also unclear when the post-season measures were obtained relative to final wildfire assignments and accumulated days off.” [1]. The methods state that post-season measurements were taken on 21 September 2017, immediately after most subjects returned to the base after final assignment.
6. “It appears that neither fat nor fat free mass demonstrated a statistically significant change and therefore was not included in the results.” [1]. Body fat percentage (BF%) is probably the most evaluated body composition component in sports [25] thus BF% and body weight were the focus of Collins et al. [2] using methods similar to those described in [26], and statistical results for these were presented. Ruby is correct that fat mass was not significant ($p = 0.057$), but incorrect regarding fat-free mass. Fat-free mass was marginally significant based on a two-tailed t-test ($p = 0.049$). This additional information was not the focus of the manuscript [2].
7. “The only valid conclusion the present data can provide is that body composition (fat mass and fat free mass) appear to remain stable over a single fire season in nine smokejumpers” [1]. Since there appears to be extremely limited research conducted on Smokejumpers that the author is aware of, besides simulated work conditions conducted on a range of WLFF in 1981 [27], Ruby [1] appears to have drawn unreferenced conclusions regarding smokejumpers and body composition. Studies have shown that athletes with regimented training and competition schedules do maintain fat mass and fat-free mass and some even see increases in lean mass but have also seen increases of BF% [28]. However, smokejumpers are unique in the wildland firefighting world with rigorous training and physical conditioning standards [29], and have only had longitudinal body composition studied by Collins et al. [2].

Given the recent upswing in large-scale wildfires coupled with longer fire seasons across the western United States, data presented in Collins et al. [2] complement other studies to enhance our understanding of the human conditions associated with wildland firefighting incidents.

Conflicts of Interest: The author declares a conflict of interest with the author of the Comment.

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