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Focal Behavior and Performance By Male U.S. Service Academy Cadets: A Preliminary Analysis

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Goal Setting and Personal Development: Teachers' Perspectives, Behavioral Strategies and Impact on Performance

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ABSTRACT

Background. (Erfle & Gelbaugh, 2013) and (Erfle, 2014) examined a regular irregularity in physical activity performance histograms for curl-ups and push-ups from a sample of more than 9,000 middle-school students. These histograms showed periodic spikes at 5 and 10 unit intervals. They showed that students who used focal counting on one event were more likely to do so on another event, or on the same event at a later assessment. They also found that students who ended at these focal endings outperformed their non-focal peers on these fitness tests. They found that males were more likely to be focal than females.

Methods. This chapter examines focal proclivity and performance using two Male U.S. Service Academy Cadet convenience sample datasets. One dataset is of 520 Cadets who did at least one pull-up, push-up, and sit-up; the other is of 301 Cadets who did at least one cadence pull-up, (CPU), and one 175-pound bench press repetition, (BP rep).

Results. Neither dataset exhibits the pronounced regular spikes seen in the middle-school data. We therefore expand our analysis to counting by bases other than 5 and 10. The BP-CPU dataset exhibits focal counting by 2, 4, 6 and 8 for BP reps and by 5s for CPU. There is limited evidence of focal counting in the Pull-Push-Sit dataset with sit-ups being the only event with significant focal counting (by base 5).

Pull-up performance by those who count by 4s have higher pull-up performance than those who do not count by 4s ($\Delta M = 0.98$, $p = .01$). Those who count BP reps by 2s and 4s significantly outperform those who do not on both BP reps and CPUs. Regression models suggest the counting BP reps by 6s leads to 2.91 more BP reps, $p < .001$, all else held constant.

INTRODUCTION

The previous chapter laid out a methodology for analyzing skip counting by various bases. This methodology however, was only conceived of because initial analysis of the Cadet data suggested that, unlike middle-school students analyzed by Erfle and Gelbaugh (2013) and Erfle (2014), Cadets exhibit little proclivity for counting by 5s. Base 5 and 10 were the obvious choices given the focal spikes at multiples of 5 and 10 in the middle-school data described in the previous chapter. Additionally, as demonstrated rather strongly in middle-school aged children, this focal counting carries over to other performances and seems to withstand the test of time thus is carried over from one testing period to another (separated by over 6-months). The strategy employed in this chapter is to examine whether evidence exists that other counting bases were used in place of 5 by Cadets undertaking physical activity performances as part of the physical education testing regime at a U.S. Service Academy.

While not the focus of the chapter, it is nonetheless helpful to broaden and briefly discuss the concept of overall muscular fatigue. After all, each activity involving multiple repetitions must have a last repetition of that activity. That last repetition counted is either due to (a) volitional fatigue, (b) a combination of central fatigue or peripheral fatigue, (c) time limitation, (d) focal behavior, or (e) some combination of those factors. Volitional exhaustion (fatigue) is operationally defined by Pitcher and Miles (1997) as the point at which a person cannot perform a muscular contraction and voluntarily terminates the contraction. Further, momentarily muscular concentric failure (MMCF) also deserves description. MMCF is a term adapted from Gießing's text (2005) which states that MMCF terminates a set when concentric failure is reached, thus the final repetition cannot be fully completed due to fatigue. Although these distinctions may seem slight, it is important to recognize that sometimes subjects will voluntarily terminate a repetition prior to concentric failure (volitional fatigue) or indeed reach failure due to the inability to perform the concentric phase of the repetition (MMCF). Most exercise repetition failures occur in the concentric phase (Fleck & Kraemer, 2014, p. 3).

Regardless, in the present context, one's force generating capacity of the working skeletal muscles are activated in the tasks and then one's (a) volitional cessation of work triumphs in the task, (b) MMCF is exhibited, (c) time runs out in the cases of the 2-minute push-up and sit-up, or (d) a combination of several factors. Not surprisingly, there are many different models as to the mechanisms by which global fatigue arises, and for this chapter we will narrow in focus to two common definitions; peripheral fatigue and central fatigue. Another important aspect of skeletal muscle fatigue is to note that fatigue is transient and is certainly reversible with rest. Overall fatigue models have been in place for over a century (Giulio, Daniele, & Tipton, 2006; Hill & Lupton, 1923). Enoka and Duchateau (2008) provide a concise description of overall muscular fatigue. They state that muscle fatigue can refer to (a) a motor deficit, (b) a perception or decline in mental function, (c) it can describe the gradual decrease in the force capacity of muscle or the endpoint of a sustained activity, and (d) it can be measured as a reduction in muscle force, a change in electromyographic activity or an exhaustion of contractile function.

Briefly, the peripheral model of fatigue centers on the energy carrying molecule, adenosine triphosphate (ATP) and the production of biological substances, their use, and subsequent creation of byproducts. Hill & Lupton in the 1920's pioneered much work related to peripheral fatigue, however one of their central tenets, that lactic acid (an apparent byproduct of exercise) causes fatigue, has been shown to be incorrect by the work of Brooks, Dubouchaud, Brown, Sicurello, and Butz, (1999). Additionally, this model purports that once a person begins to exercise, metabolites produced in the tissue give rise to limiting one's exercise work capacity. These metabolites could take on the form of increasing H^+, NH_4, P_i, or even the depletion of glucose, glycogen, Ca^{2+} release, or CrP. Since the current focus of this chapter is on the psychological aspect of performance (focal counting) we will focus on the latter model of fatigue, central fatigue.

The central model of fatigue is also widely accepted, since the occurrence of central fatigue in humans with disease, healthy humans, and in many competitive athletes and settings is well documented (Amann & Dempsey, 2008; Noakes, 2000). Characteristic of the central model of fatigue is the condition that fatigue is derived from central factors such as motivation, central nervous system transmission, and motor unit recruitment. The distinction of this fatigue is that it occurs proximal or thus upstream from the neuromuscular junction generally residing in some integrator –heart, brain, or a combination thereof. Perhaps most compelling in the central model of fatigue is what is known in some competitive circles as end spurt. End spurt is exactly what the name implies in that many performers realize that when the end is near, they are able to produce more motor unit recruitment and thus finish faster or stronger than the more recent rate of force production. This is the kick, or sprint, to the finish line in long-distance races or long distance swims. The central model, end-spurt or focal counting are, to some extent, at odds with the peripheral fatigue model because one would hypothesize that fatigue metabolites would be at their highest concentration levels towards the end of a physical performance, yet one is able to over-ride those metabolites. We believe that fatigue is an interplay of both models, however our data from middle school-age children and college-age subjects supports the fact that some central model condition in the brain, motivation or focal counting, also seems to influence performance.

The current chapter utilizes two Cadet datasets to examine whether evidence supports skip counting in this setting and whether those who did act in focal fashion outperformed their non-focal peers. Data collection methods and analytical techniques employed are discussed in the Method section followed by a Results section. The chapter ends with a Conclusion section which also discusses areas of future research.

METHOD

The Pull-Push-Sit dataset was conducted during one specific entrance day to a U.S. Service Academy, while the BP rep-CPU dataset was collected during an in-class physical assessment at the same U.S. Service Academy. For the Pull-Push-Sit data, pull-ups were conducted on a one-one basis in which the performer performed command pull-ups via the direction of a trained instructor who had a Master's Degree or higher in the field of Physical Education. After having body composition measured, participants reported to the pull-up station in shirt, gym shorts and socks. Participants were briefed by the instructor to the standards which included: Mounting the bar with pronated grip, once attaining a full-dead hang position, the instructor stated "up." Participants in a non-kipping fashion pulled directly in line and attained the chin over the pull-up bar. Instructor stated the repetition "one" and the participant returned to a full dead hang position. Once attaining a full dead hang position, the instructor stated, "up" and the participant continued in the manner described. Once the participant failed to attain their chin over the bar or maintain cadence, the instructor stated "cease work" and the participant dismounted the pull-up bar. After attaining as many pull-ups as possible in the prescribed manner, the repetitions were annotated on a standardized card and inputted into a statistical file.

Push-ups and sit-ups were tested on the same day with approximately 2-3 days separating these tests from the pull-up test depending on group assignment. Two participants for the push-ups test were placed next to one instructor for grading. The instructor was seated in a chair with participants on either side in a 45 degree alignment facing the instructor. Participants assumed a front leaning rest position with feet no more than 12 inches apart, and hands placed flat on the floor with hand-width dependent on participant's own selection. Exact instructions mirrored those found in the Army's Field Manual 7-22 page A-6 which states (United States Department of the Army, 2012):

> The push-up event measures the endurance of the chest, shoulder, and triceps muscles. On the command, 'get set', assume the front-leaning rest position by placing your hands where they are comfortable for you. Your feet may be together or up to 12 inches apart (measured between the feet). When viewed from the side, your body should form a generally straight line from your shoulders to your ankles. On the command 'go', begin the push-up by bending your elbows and lowering your entire body as a single unit until your upper arms are at least parallel to the ground. Then, return to the starting position by raising your entire body until your arms are fully extended. Your body must remain rigid in a generally straight line and move as a unit while performing each repetition. At the end of each repetition, the scorer will state the number of repetitions you have completed correctly. If you fail to keep your body generally straight, to lower your whole body until your upper arms are at least parallel to the ground, or to extend your arms completely, that repetition will not count, and the scorer will repeat the number of the last correctly performed repetition.
>
> If you fail to perform the first 10 push-ups correctly, the scorer will tell you to go to your knees and will explain your deficiencies. You will then be sent to the end of the line to be retested. After the first 10 push-ups have been performed and counted, no restarts are allowed. The test will continue, and any incorrectly performed push-ups will not be counted. An altered, front-leaning rest position is the only authorized rest position. That is, you may sag in the middle or flex your back. When flexing your back, you may bend your knees, but not to such an extent that you are supporting most of your body weight with your legs. If this occurs, your performance will be terminated. You must return to, and pause in, the correct starting position before continuing. If you rest on the ground or raise either hand or foot from the ground, your performance will be terminated. You may reposition your hands and/or feet during the event as long as they remain in contact with

> the ground at all times. Correct performance is important. You will have two minutes in which to do as many push-ups as you can. Watch this demonstration.

Participants conducted push-ups for two-minutes. Only properly executed push-ups were annotated on the standardized fitness card. Repetitions were inputted into a statistical file.

After completing the push-ups test, participants were allowed at least 10 minutes rest before embarking on the two-minute sit-up test. For the sit-up test, one instructor graded five participants on a standardized mat. Each participant had a partner who held the participant's feet in the authorized position and counted based on the instructor's feedback. The five participants on the mat were assigned a number from 1-5. Standing in a 90 degree angle from the mat, the instructor judged the sit-up performance. If one of the participants did not complete a properly executed sit-up, the instructor would state, "#2, no, go all the way up." Thus the grader would not count that sit-up and the participant would have to make the stated correction. As with push-ups, participants conducted sit-ups for 2-minutes with Army Field Manual 7-22 page A-8 standards which state (United States Department of the Army, 2012):

> The sit-up event measures the endurance of the abdominal and hip-flexor muscles. On the command 'get set', assume the starting position by lying on your back with your knees bent at a 90-degree angle. Your feet may be together or up to 12 inches apart (measured between the feet). Another person will hold your ankles with the hands only. No other method of bracing or holding the feet is authorized. The heel is the only part of your foot that must stay in contact with the ground. Your fingers must be interlocked behind your head and the backs of your hands must touch the ground. Your arms and elbows need not touch the ground. On the command, 'go', begin raising your upper body forward to, or beyond, the vertical position. The vertical position means that the base of your neck is above the base of your spine. After you have reached or surpassed the vertical position, lower your body until the bottom of your shoulder blades touch the ground. Your head, hands, arms or elbows do not have to touch the ground. At the end of each repetition, the scorer will state the number of sit-ups you have correctly performed. A repetition will not count if you fail to reach the vertical position, fail to keep your fingers interlocked behind your head, arch or bow your back and raise your buttocks off the ground to raise your upper body, or let your knees exceed a 90-degree angle. If a repetition does not count, the scorer will repeat the number of your last correctly performed sit-up. If you fail to perform the first 10 sit-ups correctly, the scorer will tell you to 'stop' and will explain your deficiencies. You will then be sent to the end of the line to be re-tested. After the first 10 sit-ups have been performed and counted, no restarts are allowed. The test will continue, and any incorrectly performed sit-ups will not be counted. The up position is the only authorized rest position.
>
> If you stop and rest in the down (starting) position, the event will be terminated. As long as you make a continuous physical effort to sit up, the event will not be terminated. You may not use your hands or any other means to pull or push yourself up to the up (rest) position or to hold yourself in the rest position. If you do so, your performance in the event will be terminated. Correct performance is important. You will have two minutes to perform as many sit-ups as you can. Watch this demonstration.

Once two-minutes was completed, the participants and "counters" reported to the instructor and the proper repetitions were recorded on the standardized fitness card. Confirmation was made between instructor, counter, and participant. Correct repetitions were inputted into a statistical file.

The Pull-Push-Sit data was stored in a computer with a specific study identification number associated with performance parameters. Data was sanitized and only 520 subjects who conducted at least one repetition in each event were included in subsequent data analysis.

The BP rep-CPU dataset was conducted during one semester of instruction. One co-author of this chapter, having at least 20 years of experience at a US Service Academy and a Ph.D. in Human Performance oversaw execution of the two physical performances. Each test was conducted on a separate day with one day rest between each test. A standardized warm-up protocol of 2 minutes of light blood flow, followed by 2-4 reps of 135 pound bench press was performed by each subject. The specific protocol for each testing session employed the protocol created in 2000 for an institutional-wide fitness assessment protocol (Department of Physical Education, West Point, 2000). The BP protocol consisted of the following guidelines for each participant.

Men place 175 pounds (Bar plus One 45 pound & Two 10 pound plates on each side)

- ☐ Have your classmate serve as a spotter, Lift this weight as many times as possible.
- ☐ Conduct full range of motion repetitions to include just slightly less than "full, lock-out" position. Additionally on descent, Cadets must use the "touch and go" method of the bar touching chest and then returning to start position. (NO BOUNCING)
- ☐ Maintain 5 points of contact: Left foot, right foot, buttocks, shoulders and head.
- ☐ The spotter may help you on the last repetition for safety, but this repetition will not count.
- ☐ Once the spotter touches the bar, no more repetitions will be counted.
- ☐ *Criterion Measure:* Number of correctly performed repetitions of the Chest (Bench) Press

Note: A STRENGTH test. Correlates highly to 1-RM strength test (r = .96), due to the high "preload" of weight (Crowder, Roper, & Johnson, 2006).

Because the score attained was factored into the performer's overall course grade, high motivation by each participant was enhanced.

The participant executed the 175-BP until reaching MMCF. More specifically related to the BP, (one complete repetition) includes taking the bar off the rack in the up position, followed by one pause (static contraction #1) then an eccentric contraction, another brief pause in the down position, (2^{nd} static contraction) followed by the concentric contraction returning to the original start position. It is on this concentric contraction (pushing the barbell up) where the majority of muscular failures occur (Fleck & Kraemer, 2014) due in part to the subject's inability for adequate motor unit recruitment to overcome the imposed demand. Only repetitions done to standard as outlined above were counted. The repetitions were annotated on a scoring sheet and transferred to an Excel spreadsheet. After one day of rest, the participants conducted the 5-second cadence pull-up (CPU). One co-author of this chapter conducted the protocol by utilizing a stopwatch and determining the proper form on execution of the CPU. All participants utilized the pronated grip on the pull-up bar. Additionally, standards codified in 2000 for the institutional-wide fitness assessment protocol pages 9-10 were employed. The specifics included (Department of Physical Education, West Point, 2000):

- ☐ Make sure your feet DO NOT touch the floor.
- ☐ On the command of "mount," jump up and grab pull-up bar, palms facing away from the performer's face (pronated grip).

- ☐ At same time, instructor or partner begins watch.
- ☐ At five second intervals, instructor/partner instructs participant to conduct a pull-up by stating “up.”
- ☐ **Participant cannot execute a pull-up until the command “up.”**
- ☐ Pull-ups are conducted on running clock of 05, 10, 15, 20, etc. until participant can no longer execute another pull-up.
- ☐ The first pull-up begins at the 05 second mark, thus a Cadet must hang before the test can begin.
- ☐ Resting greater than 5 seconds is not allowed.
- ☐ Participant must keep pace with the cadence.
- ☐ If unable to maintain pace with the cadence, the test is terminated.
- ☐ No kipping or “circus pull-ups” are allowed.
- ☐ Partner may place hand up and stop swing while in extended position, attempt to maintain vertical alignment on own.
- ☐ Participant needs to lift chin over the pull-up bar.
- ☐ Repetitions are not counted if not executed to standard.
- ☐ Partner records and verifies only the properly performed CADENCE pull-ups.

The participant executed the CPU until reaching MMCF, unable to maintain cadence or unable to meet standards outlined above. Only repetitions done to standard as outlined were counted. The repetitions were annotated on a scoring sheet and transferred to an Excel spreadsheet.

The BP-CPU data was stored in a computer with a specific study identification number associated with performance parameters. Data was sanitized and 301 subjects who conducted at least one repetition in each event were included for subsequent analysis. Excel was used for data cleaning and SPSS was used for statistical analysis. A 5% significance level based on a two-tailed test using a Bonferroni adjustment for multiple comparisons was used for statistical tests involving multiple pairwise comparisons.

There are two aspects to focal counting examined here, proclivity and performance. Proclivity examines whether subjects stop their performance at a multiple of the counting base more often than random processes would suggest. Performance examines whether those who stopped their performance at such outcomes outperformed those who did not.

RESULTS

We begin by analyzing the dataset that most closely resembles the one analyzed in the previous chapter, Pull-Push-Sit. This dataset has one new event, pull-ups, for which focal tendencies may be analyzed (because they are done in discrete units) but it does not have a continuous measure such as the mile run available for analysis. After we examine this dataset, we examine the results gleaned from the BP-CPU dataset.

Pull-Push-Sit

Figure 1 depicts the performance of the 520 Cadets from the Pull-Push-Sit dataset who performed at least one pull-up, one push-up, and one sit-up using three histograms. Mean and standard deviations for each event are also provided in a small table within the figure. The most striking aspect of these histograms is the almost complete lack of regular-irregular patterns in these performances (unlike the obvious regular spiked patterns that are present in the middle-school physical activity performance histograms in the previous chapter). This is confirmed by the statistical test results reported in Table 1.

****** Figure 1 and Table 1 about here ******

Table 1 is organized with proclivity and performance examined in groups of columns and events examined in groups of rows. Proclivity examines whether there is independence across remainder groups when the performance is divided by counting base k. Performance examines whether focal performers have performances that are systematically different than non-focal performers. Erfle and Gelbaugh (2103) and Erfle (2014) showed that focal performers outperformed their non-focal peers on fitness tests and that focal performance on one test implied superior performance on other tests as well. The difference in performance tests examined in Table 1 span both own-event performances (boxed) and cross-event performances in order to see if cross-event trends are apparent. Standardized mean difference, SMD, allows the reader to compare across events to examine effect size.

The number of focal performers is the only value listed for each k as this value provides evidence of counting by base k. Mathematically, these are the remainder 0 group when the event performance is divided by k. Situations where the number of focal performers exceeds expectations, $N_{focal} > 520/k$, provides evidence of counting by base k on this event. However, even if there are no more performers than one would expect on the basis of random processes, $N_{focal} = 520/k$, it may be the case that systematic counting strategies exist. As noted in the previous chapter, one may see systematic under-population of the “just-below” k-1 remainder group. As discussed in the previous chapter, the chi-square test allows us to test for independence across remainder groups. For example, 130 individuals had performance that ended in a multiple of 4 exactly matches 520/4. The chi-square test in this instance is not zero because the remainder 1, 2, and 3 groups were not also 130. In fact, these remainder groups had 132, 130 and 128 members, respectively. The chi-square in this instance was 0.062 which has a p value of p = .996 given 3 (k-1 with k = 4) degrees of freedom.

Performance is a separate issue from proclivity. Performance asks whether those who are focal exhibit systematic differences in the number of repetitions performed relative to non-focal performers.

The general pattern to emerge from Table 1 is one of non-significance. There is a single statistically significant proclivity result where 118 Cadets ended their sit-up performance in multiples of 5, significantly more than the 104 expected on the basis of random processes (chi-square = 10.62, p = .031 based on 4 degrees of freedom).

The same pattern of non-significance exists on the performance front. The 118 who ended their sit-up performance in multiples of 5, did, on average, 1.43 more sit-ups than their non-focal peers but this performance differential was not significant (p = .20). All 32 cross-event performance differences (not boxed) failed to achieve significance and all but one of the 16 own-event performance differences (boxed) failed to achieve significance. The sole significant performance differential is for the 130 Cadets who ended their pull-up performance in a multiple of 4. Although these Cadets did not exhibit intentionality to achieve focal counting by 4s their own-event performance was almost a full pull-up more than those achieving remainders 1, 2, or 3 when their pull-up performance is divided by 4 (mean difference = 0.98, SMD = 0.26, p = .01). This is the largest SMD in Table 1 and an SMD of this size can be characterized as being of moderate size.

BP-CPU

Figure 2 depicts the performance of the 301 Cadets from the BP-CPU dataset who performed at least one 175 pound bench press repetition (BP) and one cadence pull-up (CPU) using two histograms. Mean and standard deviations for each event as well as body mass in pounds (BM) are also provided in a small table within the figure.

****** Figure 2 about here ******

Unlike the Pull-Push-Sit dataset, the BP-CPU dataset exhibits significant intentionality for a number of counting bases for the BP event and for base 5 for CPU. Because BP reps exhibit evidence of focal counting by bases 2, 4, 6, and 8, even BP reps are shown in black. By contrast, the only significant counting base for CPU is 5 so multiples of 5 are shown in black for CPU in Figure 2

Tables 2 and 3 provide a proclivity and performance analysis for BP and CPU, respectively. The top portion of each table examines proclivity while the bottom examines performance. In both tables the counting bases k where k > mean performance/2 are shown in grayscale to distinguish them from those where more than two chances to achieve a focal outcome occur prior to attaining mean performance. As with Table 1, own-event performances are boxed to distinguish them from cross-event performances or BM differences.

****** Table 2 about here ******

Table 2 shows that evidence exists for significantly greater than average counting by bases 2, 4, 6, and 8 for BP. In each, the chi-square p value is significant at the p < .001 level. Each of these bases also shows significantly higher performance by focal performers than non-focal performers for the own-event (of 2 to 4 more BP reps). Further, for bases 2 and 4, being focal on BP has significant performance implications for CPU (of more than 1 CPU). This carry-over from one event to another is similar to middle school students with focal push-up performances having higher sit-up and mile run performances found in Erfle (2014). It is worth noting that there are no significant BM differences across focal and non-focal groups despite these performance differences.

Table 3 shows that focal CPU performance leads, in general, to no significant differences in proclivity or performance. The sole significant positive difference is for base 5 (although base 10, which is greater than half the mean performance for this event, also has significantly more focal performers than random processes would suggest). No significant performance differentials exist on the entire table. An asymmetry appears to exist between BP and CPU much like existed between push-ups and sit-ups in Erfle (2014).

****** Table 3 about here ******

Because CPU exhibits significant focal proclivity by base 5 and BP exhibits significant focal proclivity by bases 2, 4, 6, and 8, it is worthwhile to test for interactions between BP and CPU. This is shown in Table 4. The interaction of BP × CPU is most simply considered as a 2 × 2 partition because both events can be either focal or not-focal. Four such 2 × 2 partitions are examined, one for each of the significant BP bases, in vertical panels. (The last, with k = 8 for BP, should be judged with caution because 8 > mean BP performance/2 as noted above. The discussion below will therefore focus on the first three partitions.) In each panel, there are four columns, one for each cell in the partition. Let B = 175 pound bench press reps, C = cadence pull ups and read "¬" as not. The four cells are then ¬B¬C, C¬B, B¬C, and BC. Proclivity is examined in two ways: using 1-way expected frequency, EF, based on the assumption of random endings for both events; and using 2 × 2 EF based on the assumption of independence across events using actual one-way frequencies. Chi-square values are presented for each in the upper portion of Table 4. Actual frequency and EF with chi-square contribution under both assumptions provide a detailed analysis of proclivity. Mean cell performance for both events and BM are presented in the next three rows. The bottom half of Table 4 is devoted to the analysis of difference between means for both events and BM. For each, difference between means test p values are presented below diagonal and standardized mean difference, SMD = (difference between means)/standard deviation (SD) are shown above the diagonal. Boldfaced values are significant at p < .05 level.

****** Table 4 about here ******

For each of the three partitions, the 1-way chi-square is significant at p < .001 but the 2-way chi-square fails to achieve significance. The contribution to chi-square values for significant chi-square values provides an indication of which cells provide the greatest impact. In each, the greatest contribution comes from the BC cell (35% to 53%) and the smallest comes from the C¬B cell (1% to 3%). Each BC and B¬C cell exceeds expectations and each ¬B¬C cell fails to meet expectations. Put another way, focal BP is a more important contributor to systematic differences in focal proclivity than focal CPU performances.

For each of the three partitions, BP performance is greatest for B¬C cell followed by the BC cell, but it should be noted that none of these differences are significant. The superiority of focal BP performance relative to focal CPU performance is confirmed by having CPU performance higher for B¬C than C¬B although none of the differences are significant. For k = 4 and 6, ¬B¬C and C¬B are not significantly different from one another but both are significantly worse than B¬C and BC on BP performance. Both B¬C and BC are better than ¬B¬C on

CPU performance. There are no significant differences with regard to BM across cells.

Table 5 presents a regression analysis of BP and CPU performance. Each event is modeled as a function of the other event, BM, and three focal dummy variables, one for BP, one for CPU and one for BP × CPU. As in Table 4, four specifications are presented for each model. The models vary according to the counting base for BP (2, 4, 6, and 8) but each has k = 5 for CPU. Once again, the last model is presented in grayscale as care should be taken in its interpretation because 8 > mean BP performance/2.

****** Table 5 about here ******

These models perform reasonably well with 45.8% to 48.7% of the variation in BP and 39.6% to 40.2% of the variation in CPU explained by the model (according to R^2). As expected, each is a positive predictor of the other event at the $p < .001$ level. Body mass is a positive predictor of BP and a negative predictor of CPU, each at the $p < .001$ level. These coefficients are quite stable and suggest that ten extra pounds produces approximately 2 more BP reps and 1 less CPU (2 = 10·(0.2) and -1 = 10·(-0.10)). The sole significant focal variable (aside from BP with k = 8) is BP with k =6. The coefficient suggests that those whose performance is a multiple of 6 perform slightly less than 3 more BP reps than those who do not end in a multiple of 6 ($b_{FocalBP,6} = 2.91$, $p < .001$).

CONCLUSION

In examining the datasets for this chapter and linking back to the previous chapter, we essentially have different types of muscular activated performance which certainly undergo the ability to reach volitional fatigue. Regardless of outcomes or activities, a final repetition is counted as the concluding work effort. Although it is not difficult to know when one is fatigued, it is entirely another matter to be able to identify the physiological and psychological mechanisms responsible for this condition.

Just what is happening as our subjects are performing the exercises? We can only speculate and examine the data but it seems clear that many middle school students use 2, 5 and 10 as skip counting bases. Casual conversation with many people regarding counting strategies suggests that some brains seem to be wired to count, 5, 10, 15 …, or, 2, 4, 6 …, or, at the very least, use skip counting to save time. Do we have in our brains, natural focal points? In other words, if I am a focal point person, do I provide an end spurt to get me from 39 to 40?

An important aspect to consider in the discussion is the overall load at hand and to operationally define the term motor unit recruitment. Motor units in the simplest sense are the motor nerve cells and all skeletal muscle fibers this motor nerve innervates (Brooks, Fahey, & White, 1996). During push-ups subjects are dealing with approximately 64-66% of their body weight as resistance (Wurm et al., 2010), while in the BP exercise, 175 lbs was the external load. In our dataset, average subject body weight was 180 pounds, thus from 115-119 pounds is being pushed each time the push-up is performed. Conversely at least an additional 56 pounds (175 pounds total) is being pushed with each bench press repetition. It is this additional weight which causes more motor unit recruitment, (central motor drive, which activates additional motor units) which perhaps causes a subject to count by a lower base number than 5 or 10 since fewer repetitions will be performed. Is it a combination of lower repetitions and higher resistance that changes the natural focal points when comparing BP to CPU?

Before discussing artificial focal points, it is informative to discuss the central fatigue model with regard to Noakes (2012) and the central governor and integration. We discussed briefly in the introduction the key differences between the peripheral and central models of fatigue. Shei and Mickleborough (2013) provide a brief review for those seeking additional information related to these two specific global fatigue models. Noakes and colleagues have extended the fatigue theories and have contributed greatly to the development of what is now termed the "central governor model" (CGM) in which peripheral factors such as an increase in hydrogen ion concentration (H^+), or perceived heart rate serve as afferent (toward organ or target site) signals to the brain that are then processed along with other information (such as conscious thought) (Noakes, 2012; Shei & Mickleborough, 2013). Research examining some of these models have led to the notion of an integrated neural response, which ultimately results in a change in neural drive to the muscles with Amann (2012) labeling this central motor drive (CMD).

Noakes (2012) and others have postulated in the CGM that the integration of information and control of CMD takes place in the subconscious brain. Perhaps the subconscious brain is also where natural focal points occur. The manifestation of fatigue in the conscious brain is thought to be the result of the subconscious mental calculations of the central governor (Lambert, Gibson, & Noakes, 2005). It is proposed that communication between the conscious and subconscious brain takes place and that conscious thought (i.e., consciously slowing down due to fatigue or attempting to fight past fatigue) can be re-integrated in the subconscious brain (Tucker et al., 2009).

Fighting thru fatigue and being mentally tough are attributes that are highly desired in a military setting. Several studies (Edwards & Polman, 2013; Stone et al., 2012; Swart et al., 2009) have examined what happens when subjects are deceived about end points or pacing. Related to end points, exercising at unknown distance causes one to adjust pace, thus never fully knowing when to make an end spurt. Further, pacing has been shown to occur in that one generally saves back a little velocity or effort and that one generally has some metabolic reserve to apply when the end is within reach. Is the metabolic reserve, the reserve that allows one to perform one more repetition to achieve a natural focal point?

Aside from natural focal points, let us examine artificial focal points. In both the BP and CPU exercises, an existing scale was present at the U.S. Service Academy. Subjects were encouraged to perform their maximum effort, however, we believe at least one artificial focal point obviously came into play and during the writing of this chapter we also discovered a perhaps more subtle influence. Consider the scale point values attached to different BP and CPU performances in Table 6. We observe in Figure 2 that a BP focal point occurs at 24 repetitions. We believe that this is an artificial focal point caused by the point value associated with this performance in Table 6. First related to this number and score, to attain 24 reps, one has to have a significant muscular strength ability. The rate limiter for subjects in moving from 12 to 18 to 24 reps is not fatigue, but rather one's overall strength ability. In a separate analysis Crowder, Roper, and Johnson (2006) have found a correlation of $\rho = .96$ between 175 BP Repetitions and overall 1-Repetition Maximum strength tests (this test is considered the gold standard to determine overall dynamic muscular strength (Hoeger et al., 2008)). Thus, in this present case, only those individuals who have a fairly high strength ability will be able to attempt to achieve 24 repetitions. We find it interesting that many after attaining 24 reps and earning the maximum of 25 scale points, appeared to just stop at this artificial focal point. It is our belief that many subjects had additional unfatigued motor units able to continue the muscular performance task and we do not believe that almost all subjects magically attained MMCF at this point. Is this the role of artificial focal points, in that grade scales offer perhaps more influence on physical performances than we desire? Or stated another way, are there some subjects who regardless of ability are more sensitive to external rewards (artificial focal points) and will just do what is required? In our setting, we would like to believe that subjects would perform to the best of their abilities, to strive for maximum effort, in an attempt to achieve true MMCF regardless of external scale scores.

Additionally, a perhaps more subtle point that was discovered during this chapter writing process, was the exact structure of the grade scale itself. Was the grade scale itself influenced by the designer, who now in retrospect, may utilize skip counting or focal points in various performances? Note that the existing scale discounts odd BP reps except for 1 and 7 by not even providing those outcomes with their own scale point values in Table 6. Thus, when the grade scale was constructed in 2000, one of the authors subconsciously awarded even repetitions with preference over odd repetitions. Certainly the frequencies surrounding 8, 10, 12 and 14 cause one to pause and ponder as does the gap between 22 and 24. Perhaps the scale points produced a doubling impact due to both the scale points and the internal focal points or skip counting of the actual performers.

****** Table 6 about here ******

Related to the CPU, we find the results interesting, and speculate that perhaps the chart influenced slightly or created an artificial focal point. Average CPU is 8-10 repetitions for our subjects. Thus, if one can attain over 10, do they gravitate towards even numbers? Note in Table 6 that from 10- 13 repetitions, the scale only awards 0.25 additional scale points per extra repetition. Note that the even outcome of 12 is the outcome for a larger number of subjects than the odd outcomes of 11 and 13. The external reward of 0.25 scale points, would not seem to be a potential driving force for repetition motivation and in any event it provided the same incentive at 11 and 13 as it did at 12, thus was focal counting the driving force behind the difference in proclivity of the even and odd outcomes? What is also interesting, again with the caveat that one must have the enhanced pull-up ability to achieve numbers in this range, is the difference from 14 to 15 repetitions. Perhaps the scale unknowingly creates a double down ability here, in that 14 repetitions was only worth an additional 0.5 points relative to 13 but 15 is both a factor of 5, and worth 1.25 more scale points, thus providing a double bonus for the performer. Both outcomes were attained by 27 Cadets. Finally, we believe that 16 and 17 repetitions are getting very close to the upper end of performance for our subject pool and this fact alone contributes highly to the lower distribution frequencies but even here, the marginal incentive for the 17^{th} CPU is larger than the marginal incentive for the 16^{th} CPU and 11 Cadets achieved each of these outcomes. And once the scale produced no more artificial focal points, only 4 Cadets ventured into the range above 17 with one each achieving 18 through 21 CPU repetitions.

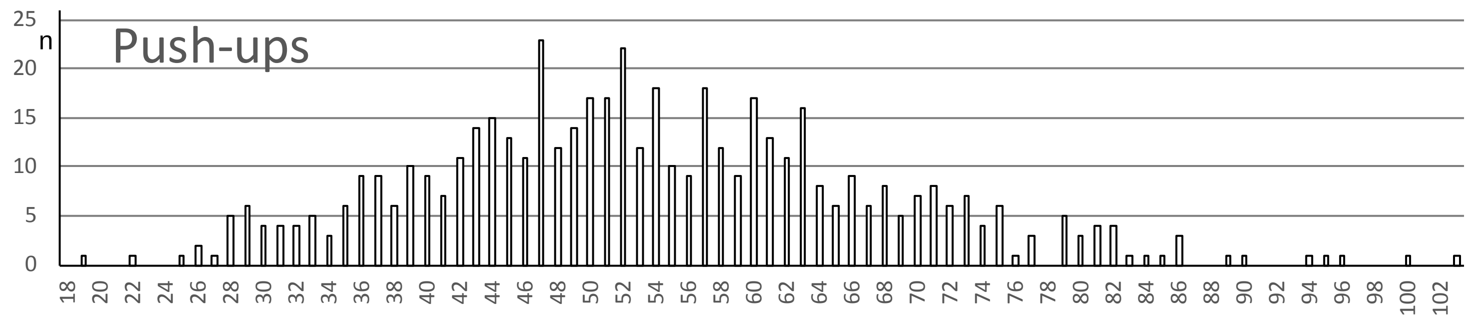
As an aside and a reinforcing view of our work at the U.S. Service Academy, we have reported that the BP and CPU, when the scale score is added together, is a field-expedient method to eliminate the influence of body mass (Crowder, Leth, Fenske, Park, & Bryan, 2008). Eliminating the influence of body mass is an important hallmark trait when examining fair fitness assessments (Vanderburgh & Crowder, 2006). Certainly the desire of fitness assessments is to compare fitness ability and not have an overly large magnitude of the performance relegated to non-fitness attributes, namely anthropometric factors (height, weight). Our data indicates that body mass is a positive predictor of BP and a negative predictor of CPU, each at the $p < .001$ level. This once again reinforces in an additional analysis that body mass is a potent influence on one's overall BP output (positive) and CPU performance (negative).

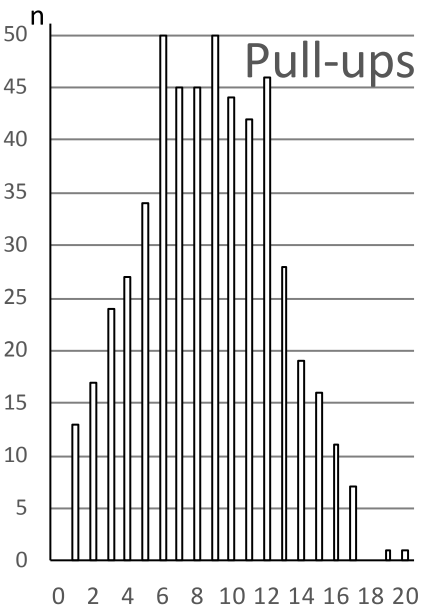
In the military setting, there is always an interplay of attempting to increase strength, yet also keeping one's cardiovascular ability high. At least in field tests assessing cardiovascular fitness, additional weight has a negative influence on running ability, a surrogate for cardiovascular fitness. Our analysis indicates that related to both BP and CPU, the body mass coefficients in Table 5 are quite stable and suggest that ten extra pounds produces approximately 2 more BP reps and 1 less CPU ($2 = 10\cdot(0.2)$ and $-1 = 10\cdot(-0.10)$). This is very applicable information to our subjects in attempting to balance the benefit of placing on additional strength output which will have to come about with extra weight gain (10 lbs = 2 more 175 lb bench press reps) and the perhaps negative influence this additional weight will have on body weight-related exercises (pull-ups, dips, running, etc.). That interplay is additionally confounded in that loaded ruck marching is easier on larger more aerobically inclined individuals compared to even smaller aerobically inclined subjects due largely to the load to body weight relationship. Although interesting to our population, caution should be exercised with this weight gain-strength output enhancement as we also did find in the same data set and reported in Table 4 that there are no significant differences with regard to body mass across cells. Thus even though we do know there is a relationship of body mass to strength output, strength output can occur not only through hypertrophy (weight gain) but from psychological-neural components; more efficient neural recruitment patterns, increased central nervous system activation, improved synchronization of motor units, lowering of neural inhibitory reflex or inhibition of the Golgi tendon organs (McArdle, Katch, and Katch, 1996).

Further research regarding these concepts of focal counting, and the distinction between natural and artificial focal points should be explored. As Erfle and Gelbaugh (2013) note in middle school aged children, boys tended to be more focal than girls. Unfortunately in our setting, college-age female Cadets are difficult to attain and small in number. Nonetheless, analysis of female Cadets should be doggedly pursued. It would be interesting to see if women at a high achieving U.S service academy employ focal counting or follow the trends of their middle school aged counterparts. Additionally, the concept of stopping at the artificial focal point has longer term interests to us. Perhaps is this an early identifier in a surrogate for mental toughness? Certainly in a military and competitive setting, mental toughness is a highly desired attribute. Is focal counting and stopping or passing an artificial focal point something that can be trained or coached? Many questions remain unanswered, however focal counting via a solely empirical view, seems to offer promise in extending our knowledge of the fatigue-endpoint model related to both body weight motor tasks and externally loaded exercises, specifically the 175-pound bench press.

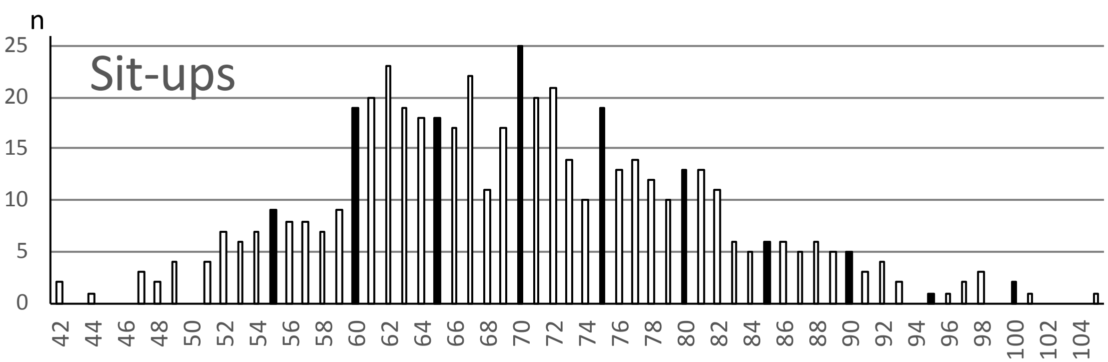
In conclusion, with these two chapters it becomes clear that we have entered into a complex intellectual arena in that we are attempting to explain fatigue during simple body weight exercises; push-ups, sit-ups, pull-ups, and the external imposed load exercise of 175-pound bench press. We believe that both natural and artificial focal points indeed have a role in attempting to explain volitional fatiguing free body weight and weight induced bench press performances. We further believe that fatigue is an interplay between the peripheral system and central control center and that both the conscious and subconscious are involved thus allowing focal point focus to have a mechanism and role in influencing fatigue and overall performance.

Figure 1. Histograms of 520 Cadets who performed at least one pull-up, one push-up, and one sit-up



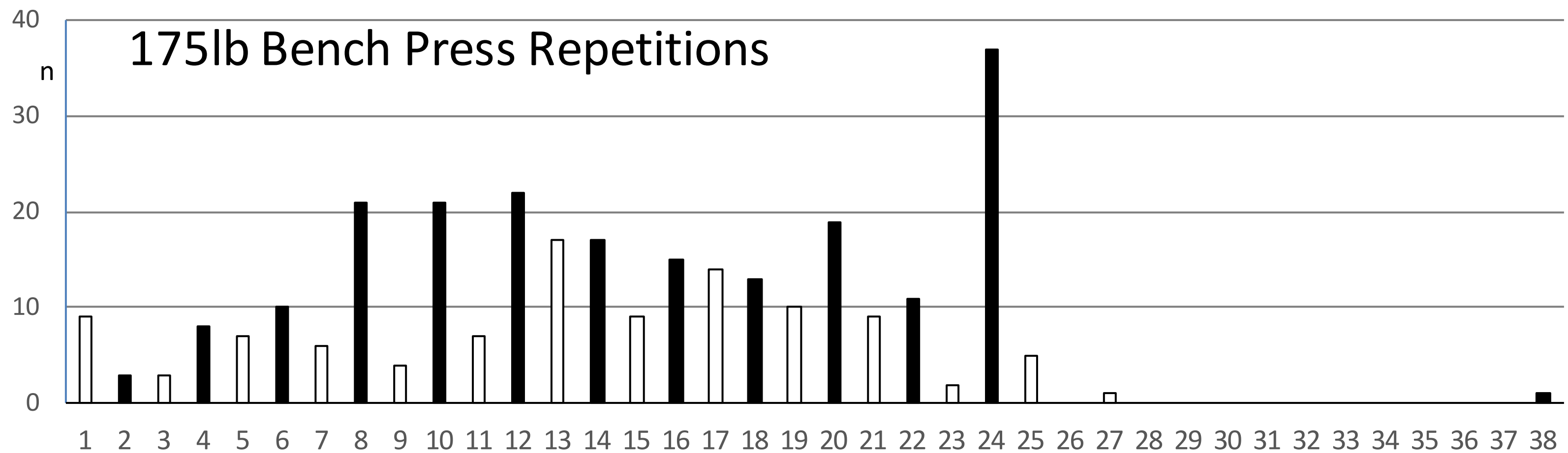


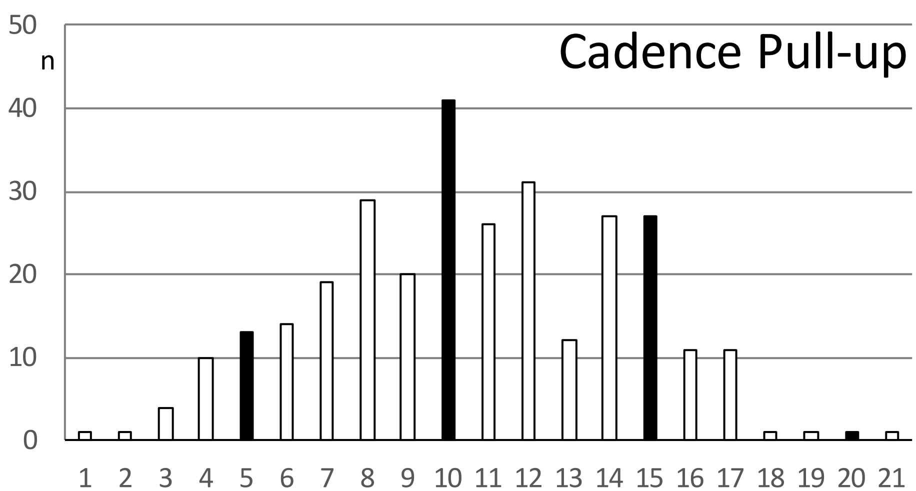
Event	Mean	Standard deviation
Pull-ups	8.6	3.8
Push-ups	53.8	13.9
Sit-ups	69.9	10.9



Note: The only event exhibiting significant focal proclivity is sit-ups in multiples of 5. These performances are denoted in black in the sit-up histogram. As noted in Table 1, there were 118 such students, 14 more than expected, p = .032.

Figure 2. Histograms of 301 Cadets who performed at least one 175 pound bench press repetition and one cadence pull-up





Event	Mean	Standard deviation
175lb BP Reps.	14.5	6.7
CPU	10.6	3.7
Body Mass (lbs.)	185	21.7

Note. Because BP reps exhibit evidence of focal counting by bases 2, 4, 6, and 8, even BP reps are show in black. By contrast, the only significant counting base for CPU is 5 so multiples of 5 are shown in black for CPU. See Tables 2 and 3 for details.

Table 1. *Do Cadets use Skip-Counting to Perform Physical Fitness Tests? Proclivity and Performance of 520 Cadets Engaged in Focal Counting by Various Bases, k, on Three Events*

Focal event	Base k	Expected N = 520/k	Proclivity			Difference in Performance, Independent samples t-test								
						Pull-ups			Push-ups			Sit-ups		
			Actual N focal	χ^2 (df=k-1)	p	ΔMeans	SMD	p	ΔMeans	SMD	p	ΔMeans	SMD	p
Pull-ups	2	260.0	260	0	1	0.12	0.03	.72	2.15	0.15	.08	1.71	0.16	.07
	3	173.3	186	1.44	.49	0.10	0.03	.78	1.00	0.07	.44	-0.97	-0.09	.32
	4	130.0	130	0.06	.996	**0.98**	**0.26**	**.01**	1.59	0.11	.27	0.97	0.09	.37
	5	104.0	95	4.27	.37	0.66	0.17	.12	0.28	0.02	.86	0.69	0.06	.56
Push-ups	2	260.0	256	0.12	.73	0.15	0.04	.66	0.09	0.01	.94	-0.42	-0.04	.66
	3	173.3	184	1.09	.58	-0.04	-0.01	.90	0.50	0.04	.68	-1.85	-0.17	.07
	4	130.0	131	1.02	.80	-0.24	-0.06	.55	-1.09	-0.08	.43	-1.85	-0.17	.09
	5	104.0	103	2.85	.58	-0.30	-0.08	.46	1.45	0.10	.37	-1.21	-0.11	.29
	6	86.7	89	1.31	.93	0.14	0.04	.75	-0.24	-0.02	.88	-2.13	-0.19	.14
	10	52.0	59	7.27	.61	-0.60	-0.16	.21	1.84	0.13	.36	-1.16	-0.11	.39
Sit-ups	2	260.0	259	0.01	.93	-0.01	-0.003	.97	0.25	0.02	.84	0.32	0.03	.74
	3	173.3	179	1.11	.57	-0.13	-0.03	.71	-0.80	-0.06	.51	-0.39	-0.04	.70
	4	130.0	131	0.05	.997	0.30	0.08	.43	0.70	0.05	.64	-0.14	-0.01	.90
	5	104.0	**118**	**10.62**	**.031**	-0.12	-0.03	.77	1.52	0.11	.30	1.43	0.13	.20
	6	86.7	91	1.26	.94	-0.55	-0.14	.21	-0.44	-0.03	.77	-1.70	-0.16	.18
	10	52.0	64	16.42	.059	0.06	0.02	.91	0.77	0.06	.69	1.88	0.17	.18

Abbreviations and notes: A performance is focal it has remainder 0 when divided by the counting base, k. Proclivity χ^2 test assumes random remainders. $Mean_{Focal}$ - $Mean_{Non\text{-}focal}$ = ΔMeans, and standardized mean difference (Cohen's d), is SMD = (Δ Means)/standarc deviation (SD). Full sample mean (SD) is 8.6 (3.85) for pull-ups, 53.8 (13.9) for push-ups, and 69.9 (10.9) for sit-ups. Sample excludes 18 Cadets with Pull-ups = 0 (of 538). Boldfaced values are significant at the p < .05 level. Own-event focal performance differences are boxed. Pull-up counting base 5 is set to grayscale because 5 > mean pull-up performance/2.

Table 2. *Focal Proclivity and Performance Analysis of Counting Bench Press Repetitions by various Bases by 301 US Military Academy Cadets who performed at least one 175 pound Bench Press Repetition and one Cadence Pull-Up*

		Base, k =	2	3	4	5	6	7	8	9	10	11
		EF = 301/k =	150.5	100.3	75.3	60.2	50.2	43.0	37.6	33.4	30.1	27.4
BP Rep Focal Proclivity												
		Focal BP rep frequency	**198**	108	**122**	61	**82**	32	**73**	**18**	40	18
		Chi-square p	**< .001**	.349	**< .001**	.908	**< .001**	.070	**< .001**	**.005**	.057	.060
Mean Performance Analysis (own-event focal performances boxed)												
Focal on BP reps	BP reps	Focal	**15.15**	**17.06**	**16.16**	14.51	**17.63**	14.66	**17.75**	16.50	14.75	**17.72**
		not Focal	**13.39**	**13.15**	**13.45**	14.56	**13.39**	14.54	**13.52**	14.42	14.52	**14.35**
		SMD	**0.26**	**0.58**	**0.40**	-0.01	**0.63**	0.02	**0.63**	0.31	0.03	**0.50**
		p	**.031**	**<.001**	**<.001**	.959	**<.001**	.924	**<.001**	.205	.839	**.039**
	CPU	Focal	**11.04**	11.09	**11.25**	10.85	11.24	10.66	11.03	12.00	11.40	11.28
		not Focal	**9.83**	10.36	**10.19**	10.56	10.39	10.62	10.49	10.53	10.50	10.58
		SMD	**0.33**	0.20	**0.29**	0.08	0.23	0.01	0.14	0.40	0.24	0.19
		p	**.007**	.098	**.014**	.586	.074	.955	.282	.103	.153	.438
	BM	Focal	184.5	187.9	186.3	186.5	187.7	185.7	188.6	187.7	183.7	189.1
		not Focal	185.0	182.9	183.6	184.3	183.6	184.6	183.5	184.5	184.9	184.4
		SMD	-0.02	0.23	0.12	0.10	0.19	0.05	0.23	0.15	-0.05	0.22
		p	.856	.055	.300	.478	.143	.793	.081	.545	.747	.376

Abbreviations: A performance is Focal on an event if the performance has remainder 0 when divided by the base. BP reps = 175 pound bench press repetitions. CPU = cadence pull up. BM = body mass in pounds. EF = Expected Frequency. Standardized Mean Difference, SMD, also known as Cohen's d, is calculated as SMD = (Focal mean - not Focal mean)/standard deviation (SD). Sample excludes 14 Cadets with BP rep = 0. Chi-square tests based on random endings for bases from 2 to 11 for each event. Mean (SD) is 14.5 (6.73) for BP reps, 10.6 (3.70) for CPU, and 184.7 (21.7) for BM. A focal proclivity that is below random processes expectations is denoted with an underscore. Boldfaced results are significant at the 5% level based on a two-tail test and performance results with bases greater than mean performance/2 are shown in grayscale.

Table 3. *Focal Proclivity and Performance Analysis of Counting Cadence Pull-Ups by various Bases by 301 US Military Academy Cadets who performed at least one 175 pound Bench Press Repetition and one Cadence Pull-Up*

	Base, k =	2	3	4	5	6	7	8	9	10	11
	EF = 301/k =	150.5	100.3	75.3	60.2	50.2	43.0	37.6	33.4	30.1	27.4
CPU Focal Proclivity											
	Focal CPU rep frequency	166	98	82	**82**	46	47	40	**21**	**42**	26
	Chi-square p	.074	.775	.369	**.002**	.519	.510	.679	**.022**	**.022**	.785
Mean Performance Analysis (own-event focal performances boxed)											
Focal on CPU: BP reps	Focal	14.64	14.37	14.06	14.01	13.93	15.45	15.00	13.81	14.40	14.65
	not Focal	14.43	14.64	14.73	14.75	14.66	14.38	14.48	14.60	14.57	14.54
	SMD	0.03	-0.04	-0.10	-0.11	-0.11	0.16	0.08	-0.12	-0.02	0.02
	p	.783	.747	.443	.399	.503	.320	.649	.603	.882	.933
Focal on CPU: CPU	Focal	10.43	11.14	10.24	10.98	10.30	11.32	10.20	9.43	10.24	11.00
	not Focal	10.85	10.37	10.76	10.49	10.68	10.49	10.69	10.71	10.68	10.59
	SMD	-0.11	0.21	-0.14	0.13	-0.10	0.22	-0.13	-0.35	-0.12	0.11
	p	.330	.089	.280	.310	.529	.160	.440	.126	.470	.586
Focal on CPU: BM	Focal	185.8	181.6	187.1	183.2	184.1	180.0	187.7	185.3	187.2	186.0
	not Focal	183.4	186.2	183.8	185.3	184.8	185.6	184.3	184.7	184.3	184.6
	SMD	0.11	-0.21	0.15	-0.10	-0.03	-0.25	0.16	0.03	0.13	0.07
	p	.334	.086	.237	.457	.848	.110	.357	.895	.420	.747

Abbreviations: A performance is Focal on an event if the performance has remainder 0 when divided by the base. BP reps = 175 pound bench press repetitions. CPU = cadence pull up. BM = body mass in pounds. EF = Expected Frequency. Standardized Mean Difference, SMD, also known as Cohen's d, is calculated as SMD = (Focal mean - not Focal mean)/standard deviation (SD). Sample excludes 14 Cadets with BP rep = 0. Chi-square tests based on random endings for bases from 2 to 11 for each event. Mean (SD) is 14.5 (6.73) for BP reps, 10.6 (3.70) for CPU, and 184.7 (21.7) for BM. A focal proclivity that is below random processes expectations is denoted with an underscore. Boldfaced results are significant at the 5% level based on a two-tail test and performance results with bases greater than mean performance/2 are shown in grayscale.

Table 4. *Proclivity and Performance for Four Bench Press Repetition Counting Schemes by Counting by Fives for Cadence Pull-ups*

	BP rep count:	× 2s				× 4s				× 6s				× 8s			
		One-way		2 × 2		One-way		2 × 2		One-way		2 × 2		One-way		2 × 2	
	χ^2, two-tail p	**41.5, <.001**		0.08, .892		**48.7, <.001**		0.34, .599		**36.5, <.001**		0.23, .664		**51.4, <.001**		**4.33, .049**	
	Focal subsample:	**¬B¬C**	**C¬B**	**B¬C**	**BC**	**¬B¬C**	**C¬B**	**B¬C**	**BC**	**¬B¬C**	**C¬B**	**B¬C**	**BC**	**¬B¬C**	**C¬B**	**B¬C**	**BC**
Proclivity	Actual frequency	76	27	143	55	128	51	91	31	161	58	58	24	159	69	60	13
	1-way EF	120.4	30.1	120.4	30.1	180.6	45.2	60.2	15.1	200.7	50.2	40.1	10.0	210.7	52.7	30.1	7.5
	χ^2 contribution	**39%**	**1%**	**10%**	**50%**	**31%**	**2%**	**32%**	**35%**	**22%**	**3%**	**22%**	**53%**	**25%**	**10%**	**58%**	**8%**
	2 × 2 EF	74.9	28.1	144.1	53.9	130.2	48.8	88.8	33.2	159.3	59.7	59.7	22.3	165.9	62.1	53.1	19.9
	χ^2 contribution	18%	48%	9%	25%	11%	29%	16%	43%	7%	20%	20%	53%	**7%**	**18%**	**21%**	**55%**
Mean Performance	BP reps	13.66	12.63	15.33	14.69	13.70	12.80	16.22	16.00	13.58	12.88	18.00	16.75	13.72	13.06	17.47	19.08
	CPU	9.63	10.37	10.94	11.27	9.99	10.69	11.19	11.45	10.22	10.86	11.24	11.25	10.30	10.94	11.00	11.15
	BM	186.3	181.4	184.7	184.1	184.5	181.4	186.4	186.0	184.5	181.1	187.5	188.2	184.4	181.3	187.6	193.2
Difference between means tests **BP reps, B**	**¬B¬C**	p\SMD	-0.15	0.25	0.15	p\SMD	-0.13	**0.37**	0.34	p\SMD	-0.10	**0.66**	**0.47**	p\SMD	-0.10	**0.56**	**0.80**
	C¬B	.494		0.40	0.31	.413		**0.51**	**0.48**	.482		**0.76**	**0.58**	.478		**0.66**	**0.89**
	B¬C	.080	.056		-0.09	**.006**	**.003**		-0.03	**<.001**	**<.001**		-0.19	**<.001**	**<.001**		0.24
	BC	.385	.191	.549		.084	**.035**	.873		**.026**	**.014**	.427		**.005**	**.002**	.419	
CPU, C	**¬B¬C**	p\SMD	0.20	**0.35**	**0.44**	p\SMD	0.19	**0.32**	**0.39**	p\SMD	0.17	0.28	0.28	p\SMD	0.17	0.19	0.23
	C¬B	.369		0.16	0.24	.255		0.14	0.21	.255		0.10	0.10	.227		0.02	0.06
	B¬C	**.012**	.456		0.09	**.018**	.436		0.07	.071	.580		0.00	.210	.929		0.04
	BC	**.012**	.296	.573		**.048**	.361	.729		.202	.665	.992		.422	.850	.892	
BM	**¬B¬C**	p\SMD	-0.23	-0.07	-0.10	p\SMD	-0.14	0.09	0.07	p\SMD	-0.16	0.14	0.17	p\SMD	-0.14	0.14	0.41
	C¬B	.314		0.15	0.12	.396		0.23	0.21	.311		0.29	0.33	.317		0.29	0.55
	B¬C	.608	.466		-0.03	.534	.197		-0.01	.363	.113		0.03	.339	.102		0.26
	BC	.559	.602	.847		.726	.355	.943		.433	.179	.894		.159	.069	.392	

Abbreviations and notes: A focal performance has remainder 0 when divided by the base. B = 175lb bench press reps. C = cadence pull up. BM = body mass in pounds, read "¬" as not. 1-way expected frequency, EF, based on random endings for both events; 2 × 2 EF assumes independence across events using actual one-way frequencies. Difference between means test p values below diagonal and standardized mean difference, SMD = (difference between means)/standard deviation (SD) above diagonal. Excludes 14 Cadets with BP rep = 0. Boldfaced values are significant at p < .05 level.

Table 5. *Regression Analysis of Bench Press Repetition and Cadence Pull-up Performances for various Focal Counting Schemes*

Dependent variable:	175 pound Bench Press Repetitions				Cadence Pull-ups			
BP rep count base, k:	× 2s	× 4s	× 6s	× 8s	× 2s	× 4s	× 6s	× 8s
Intercept	-32.1 ***	-31.4 ***	-30.8 ***	-30.7 ***	24.5 ***	24.8 ***	25.0 ***	25.0 ***
	3.1	3.1	3.0	3.0	1.5	1.5	1.5	1.5
BP reps					**0.32** ***	**0.32** ***	**0.33** ***	**0.33** ***
					0.028	**0.028**	**0.029**	**0.029**
CPU	**0.95** ***	**0.94** ***	**0.91** ***	**0.93** ***				
	0.084	**0.084**	**0.082**	**0.082**				
BM	**0.20** ***	**0.19** ***	**0.19** ***	**0.19** ***	**-0.10** ***	**-0.10** ***	**-0.10** ***	**-0.10** ***
	0.014	**0.014**	**0.014**	**0.014**	**0.0086**	**0.0086**	**0.0087**	**0.0087**
Focal BP,k	0.74 .30	1.04 .13	**2.91** ***	**2.49** ***	0.62 .13	0.59 .14	-0.10 .83	-0.20 .66
	0.72	0.69	**0.75**	**0.74**	0.41	0.40	0.46	0.45
Focal CPU,5	-0.76 .50	-0.95 .25	-0.65 .39	-0.67 .34	0.56 .39	0.66 .17	0.52 .24	0.54 .20
	1.12	0.83	0.75	0.70	0.65	0.48	0.44	0.42
Focal BP,k × CPU,5	-0.058 .97	0.55 .68	-0.74 .59	1.06 .52	-0.095 .90	-0.36 .64	-0.031 .97	-0.32 .74
	1.37	1.32	1.40	1.65	0.79	0.77	0.83	0.98
R^2	.458	.463	.487	.485	.402	.401	.396	.397

Abbreviations: BP reps = 175 pound bench press repetitions. CPU = cadence pull up. BM = body mass in pounds. Four bases are examined for BP rep counting base, k (k = 2, 4, 6, and 8) and 5 is base for CPU. Raw regression coefficients with standard error below and p value next to coefficient. Significance levels shown if $p > .05$, all significant coefficients are denoted *** and are significant at the $p < .001$ level. All F statistics are significant at the $p < .001$ level. Each focal dummy variable equals 1 if the performance has remainder 0 when divided by k, else 0. Each regression based on N = 301 cadets having BP reps > 0 and CUP > 0 and excludes 14 Cadets with BP rep = 0.

Table 6. *Point Values for 175 Pound Bench Press and Cadence Pull-up Performances Posted at a U. S. Service Academy*

175 pound bench press				Cadence pull-up		
175lb BP reps	**Scale points**	**Marginal point values, m**	**Average payout per extra rep, A = m/Dreps**	**CPU reps**	**Scale points**	**m = A**
24	**25 ***(100%)**	1	**0.5**			
23	24	0	0			
22	**24**	**0.5**	**0.25**			
21	23.5	0	0			
20	**23.5**	**0.5**	**0.25**			
19	23	0	0			
18	**23**	**0.5**	**0.25**			
17	22.5	0	0	**17**	**25 ***(100%)**	**1.5**
16	**22.5**	**0.5**	**0.25**	**16**	**23.5**	**1**
15	22	0	0	**15**	**22.5**	**1.25**
14	**22**	**0.75**	**0.375**	**14**	**21.25 *(85%)**	**0.5**
13	21.25	0	0	**13**	**20.75**	**0.25**
12	**21.25 *(85%)**	**0.75**	**0.375**	**12**	**20.5**	**0.25**
11	20.5	0	0	**11**	**20.25**	**0.25**
10	**20.5**	**0.5**	**0.25**	**10**	**20**	**0.5**
9	20	0	0	**9**	**19.5**	**0.5**
8	**20**	**0.5**	**0.5**	**8**	**19**	**1**
7	**19.5**	**0.5**	**0.5**	**7**	**18**	**0.5**
6	**19**	**1.5**	**0.75**	**6**	**17.5**	**0.5**
5	17.5	0	0	**5**	**17**	**0.5**
4	**17.5**	**0.5**	**0.25**	**4**	**16.5**	**0.5**
3	17	0	0	**3**	**16**	**8**
2	**17**	**1**	**1**	**2**	**8**	**4**
1	**16**	**16**	**16**	**1**	**4**	**4**

Source. **Boldface** repetition levels were posted on the Department of Physical Education Performance Muscular Performance Sheet, U. S. Service Academy, West Point. Normal typeface (and smaller font) repetition levels are not posted and are provided with the scale point value as one repetition less.
Note. Marginal point value, m, is the increment in scale points for the last repetition. Average payout, A, is the average increment in scale points for one more repetition from the last listed scale point value.

REFERENCES

Amann M. (2011). Central and peripheral fatigue: Interaction during cycling exercise in human. *Medicine and Science in Sports and Exercise, 43* 2039-2045.

Amann, M., & Dempsey, J. A. (2008). Locomotor muscle fatigue modifies central motor drive in healthy humans and imposes a limitation to exercise performance. *The Journal of Physiology*, *586*(1), 161-183.

Brooks, G. A., Fahey, T. D., & White, T. P. (1996). *Exercise physiology: Human bioenergetics and its applications. 2nd edition*. London: Mayfield Publishing Company.

Brooks, G. A., Dubouchaud, H., Brown, M., Sicurello, J. P., & Butz, C. E. (1999). Role of mitochondrial lactate dehydrogenase and lactate oxidation in the intracellular lactate shuttle. *Proceedings of the National Academy of Sciences 96*, 1129-1134.

Crowder, T. A., Leth, A. D., Fenske, B. D., Park, R., & Bryan, J. W. (2008). A "field-expedient" upper body muscular strength-endurance assessment which mitigates body mass influence in college-age men. *Medicine and Science in Sports and Exercise, 40*(5), S427.

Crowder, T. A., Roper, S. D., & Johnson, C. A. (2006). 175-pound bench press in college-age men; an alternative to the 225-pound or 1-repetition maximum bench press. *Medicine and Science in Sports and Exercise, 38*(5), S297.

Department of Physical Education, West Point. (2000). *Internal US Service Academy Sharepoint document.* Unpublished manuscript.

Edwards, A., & Polman, R. (2013). Pacing and awareness: Brain regulation of physical activity. *Sports Medicine*, *43*(11), 1057-1064.

Enoka, R. M., & Duchateau, J. (2008). Muscle fatigue: What, why and how it influences muscle function. *The Journal of Physiology, 586*(1), 11-23.

Erfle, S. E. (2014). Persistent focal behavior and physical activity performance. *Measurement in Physical Education & Exercise Science, 18*(3), 168-183.

Erfle, S. E., & Gelbaugh, C. M. (2013). Physical activity performance of focal middle school students. *Measurement in Physical Education & Exercise Science, 17*(2), 150-166.

Fleck, S., Kraemer, W. (2014). *Designing Resistance Training Programs. 4th edition.* Champaign: Human Kinetics.

Gießing, J., Frohlich, M., Preuss, P. (2005). *Current Results of Strength Training Research.* Gottingen: Cuvillier Verlag Press.

Giulio, C. D., Daniele, F., & Tipton, C. M. (2006). Angelo mosso and muscular fatigue: 116 years after the first congress of physiologists: IUPS commemoration. *Advances in Physiology Education, 30*(2), 51-57. doi:10.1152/advan.00041.2005.

Hill, A. V., Long, C. N. H., & Lupton, H. (1924). Muscular exercise, lactic acid, and the supply and utilization of oxygen. *Quarterly Journal of Medicine, 16*, 84-138.

Hoeger, W. W. K., Hoeger, S. A., (2005). *Lifetime Physical Fitness and Wellness, 8th edition*. Belmont, CA, Thomson Wadsworth.

Lambert, E. V., St Clair Gibson, A., & Noakes, T. D. (2005). Complex systems model of fatigue: Integrative homoeostatic control of peripheral physiological systems during exercise in humans. *British Journal of Sports Medicine, 39*(1), 52-62.

McArdle, W., Katch, F., & Katch, V., (1996). *Exercise Physiology*. Baltimore: Williams & Wilkins.

Noakes, T. D. (2000). Physiological models to understand exercise fatigue and the adaptations that predict or enhance athletic performance. *Scandinavian Journal of Medicine & Science in Sports, 10*(3), 123-145.

Noakes, T. D. (2012). The Central Governor Model in 2012: Eight new papers deepen our understanding of the regulation of human exercise performance. *British Journal of Sports Medicine, 46*(1), 1-3. doi:10.1136/bjsports-2011-090811

Pitcher, J.B., & Miles, T.S. (1997). Influence of muscle blood flow on fatigue during intermittent human hand-grip exercise and recovery. *Clinical and Experimental Pharmacology and Physiology, (24)*, 471-476

Shei, R., & Mickleborough, T. D. (2013). Relative contributions of central and peripheral factors in human muscle fatigue during exercise: A brief review. *Journal of Exercise Physiology Online, 16*(6), 1-17.

Stone, M. R., Thomas, K., Wilkinson, M., Jones, A. M., Gibson, A. S., & Thompson, K. G. (2012). Effects of deception on exercise performance: Implications for determinants of fatigue in humans. *Medicine and Science in Sports and Exercise, 44*, 534-541

Swart, J., Lamberts, R. P., Lambert, M. I., Lambert, E. V., Woolrich, R. W., Johnston, S., & Noakes, T. D. (2009). Exercising with reserve: Exercise regulation by perceived exertion in relation to duration of exercise and knowledge of endpoint. *British Journal of Sports Medicine*, *43*(10), 775-781.

Tucker, R,, Swart, J., Lamberts, R. P., Lambert, M. I., Lambert, E. V., Woolrich, R. W., Thompson, K. G. (2009). The anticipatory regulation of performance: The physiological basis for pacing strategies and the development of a perception-based model for exercise performance. *British Journal of Sports Medicine, 43*(10), 392-400.

United States Department of the Army. (2012). *Field manual FM 7-22 Army physical readiness training*. Washington, DC: Army Knowledge Online. http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/fm7_22.pdf

Vanderburgh, P. and Crowder, T., (2006). Body Mass Penalties in the Physical Fitness Tests of the Army, Air Force, and Navy. *Military Medicine, 171*, 753-756.

Wurm, B., VanderZanden, T. L., Spadavecchia, M., Durocher, J., Bickham, C., Petushek, E. J., & Ebben, W. P. (2010). Kinetic analysis of several variations of push-ups. *International Symposium on Biomechanics in Sports: Conference Proceedings Archive, 28*, 1-4.

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