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Chaos in Strength and Conditioning Terminology

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ABSTRACT

The field of strength and conditioning (S&C), has been inundated with numerous, overlapping terms leading to miscommunication between athletes, sport coaches, strength & conditioning coaches (SCC), and sport scientists. Specifically, the use of various hyphenated terms to describe strength, in combination with debate associated with the proper definition and use of power, warrants the necessity to come to agreement on consistent terminology usage. Considerations should be based on the level of applicability and understanding of those most effected (athlete, sport coach, SCC, sport scientist). Moreover, while the use of kinetic and kinematic variables in describing strength and power related qualities is not incorrect, the population receiving the information must be considered. Athletes and sport coaches may be more influenced by simple cues and descriptors used to create movement intent and overall "buy-in" to the S&C plan. Furthermore, SCC may be more concerned with how an exercise or movement will relate to improved sport performance while sport scientists may be more interested with how a specific variable(s) can be measured and quantified. Should the use of ambiguous, overlapping, or complex terminology persist, each of the various populations listed may continue to talk past one another instead of striving to be in agreeance with one another. Thus, the primary objectives of this article are to advance the field by creating an open discourse between the various individuals involved with the S&C profession while simultaneously shedding light on uncertainty associated with overlapping terms used to describe strength, power and other physical qualities associated with sports performance.

Keywords: Terminology; Physical Qualities; Biomechanical Terms; Coaching Cues; Strength; Power

INTRODUCTION

The profession of strength and conditioning (S&C) has grown throughout modern time. Implementing research, critical thinking in programming, and the assessing/development of specific physical qualities has created terms that have multiple meanings or overlaps with other terminology. For example, the general coaching description of an athlete's ability to develop "explosive-strength", in a S&C program may have created confusion between athletes, sport coaches, strength and conditioning coaches (SCC), and sport scientists due to the multiple descriptions (7,11,20,22,35). Moreover, the specific kinetic term of muscular power to describe physical characteristics of an athlete and measure of watts describing physical characteristics of an athlete, has been challenged as being misused as a sport science term (12,30). The use of different terms may be influenced by a person's highest education level completed, area of study (e.g., business), literature read, quality of mentoring, experiences of mentors, previous and current sport participation, and last of all the willingness to learn new concepts as has demonstrated SCC knowledge is influenced by level of education and certification (15). The range of terms used to describe athletic performance, exercise selection, physical performance, mainstream terminology, coaching terminology, and exercise science terminology (e.g., kinetics) can have overlap, such as "strength" (Table 1). The terms in this article may cause confusion, which is the point of the article addressing the continuous

bifurcations of S&C terms by coaches, personal trainers, academics, and sport scientists.

POWER TERMINOLOGY AND DEVELOPMENT

Coaches have described developing power in athletes by using weightlifting, plyometric, medicine ball, and sprints in S&C programs, while there has been further delineation with the terms of explosive-strength, high-speed strength, low-speed strength, strength-speed, and speed-strength exercises (1, 2, 5, 16). The context of terminology influences the exercise selection process in programming requiring the training location to determine if kinetic or kinematic variables (e.g. rate of force development), physical quality descriptions (e.g. muscular power), or ambiguous descriptor (e.g. explosive) will be used to classify exercises (11, 20, 26, 34). An advantage of using of kinetic and kinematic terms for exercise classifications allow the ability for objective units of measurement (e.g. watts) to be obtained during training (e.g. force platforms, linear position transducer, video analysis apps) (6,30).

Although these biomechanical terms can be used, the use may be challenging to disseminate why they are important to persons that are not educated in the profession while physical quality terminology (e.g., strength-speed) would be more applicable to specific exercise/movement classifications (1, 20, 34). Commonly used physical quality/athletic performance terms of strength and speed may be easier for an athlete to understand, while referring to a movement as "explosive" is ambiguous (4, 11). This term has been used to describe quickness, initial movement, expression of power (7, 19, 31) and other variations thus making "explosive" more

Table 1. Definitions of Strength Derivatives

- Accelerative Strength: Moving relative heavy loads as fast as possible. (13)
- Explosive-strength:
  - The greatest amount of force developed in a very brief time period (11).
  - The rate at which force is expressed during a sporting movement (7).
  - The ratio of maximal force over the time to peak force (35).
  - The ability of a given muscle or group of muscles to generate muscular force at high velocities. (20)
  - The ability to produce high peak rates of force development and is related to the ability to accelerate objects, including body mass. (22)
- High-speed muscular strength: The ability of muscle tissue to exert high force while contracting at a high speed. (16)
- Low-speed muscular strength – The force a muscle or muscle group can exert in one maximal effort while maintaining proper form; and involve relatively low movement speeds. (16)
- Rate of force development: The rate at which force is developed. (1)
- Speed-strength:
  - The ability to develop force rapidly and at high velocities. (1)
  - How well an athlete applies force with speed. Speed is more vital than strength. (11)
  - Schemes that are performed where rate of production (velocity) takes precedence over force, making (load) secondary in nature. (18)
  - The ability of a given muscle or group of muscles to generate muscular force at intermediate velocities. (20)
  - Movement of lighter loads with more acceleration. (26)
- Strength-speed:
  - Rapid movements against heavy loads. Strength is more vital than speed. (11)
  - A protocol (load) requires near maximum to moderate muscular contractions to execute a repetition with a secondary emphasis on the rate of production (velocity). (18)
  - The ability of a given muscle or group of muscles to generate muscular force at low velocities. (20)
  - Movements with a relatively heavy load lifted as fast as possible. (26)
- Starting strength:
  - The measurement of how fast and forceful the athletic motion is at the beginning. (11)
  - The ability to rapidly overcome inertia from a dead stop. (2)

for coaching instructions and less as an exercise/ movement classification unless context is provided.

Although explosive may not be the best choice for exercise classification, Tuten, Knight, and Moore (28) defined power as the combination of strength and speed on the application of strength to an "explosive" movement. This definition is closely related to the previous physical quality term thus raising the question, should the terms for exercises vary based on a scientific or applied context? Likewise, power has been described as movements that have been produced by the optimal combination of speed and strength (3). Sports inherently create classifications that provides SCC lists to select an exercise(s) most specific to the physical quality(s) needed to be developed into a S&C training program resulting in sport performance success (32). This viewpoint is supported by Young (32) statement, "The ability to generate relatively high forces against large resistances (strength) and to produce a high work rate (power) is important for various sports." If this statement is interpreted as a suggestion that training should stimulate the qualities needed in a sport to improve performance, then exercise selections need to be as specific to the physical qualities as possible. One barrier to effective exercise selection and S&C programming development is the overlap of terminology, varied descriptors, and disagreements over terminology that describes power, strength, etc. (1, 12, 20, 27, 29, 31). Therefore, there is a necessity to consolidate terms for communication consistency and improving S&C planning between sport coaches, SCC, sports medicine team, and athletes.

CONFOUNDING STRENGTH DEFINITIONS

The term strength or use of the term has added layers of confusion to exercise selection as it has been used as a stand-alone description, while it has also been combined with other terms of speed or explosive. These hyphenated or combined terms complicates the programming as the lines between what is a strength and power exercise are blurred, even further when strength-power is the descriptor. Strength terminology has evolved to varied definitions, descriptions, or levels such as muscular strength, maximal strength, absolute strength, maximum voluntary strength, and absolute maximum strength as presented below:

- Absolute Maximum Strength – the greatest amount of strength that a muscle or one or more group of muscles are capable of producing and can be determined isometrically or dynamically. (22)
- Absolute Strength – the greatest force which can be produced by a given muscle group under involuntary muscle stimulation (20); the protocol (load) requires maximum muscular contraction to execute a repetition at or near a 1-rep maximum regardless of the rate of production (velocity) (18).
- Muscular Strength – the ability to exert force; the contractive force of the muscle, as a result of a single maximum effort. (23)
- Maximal Strength – the ability of a particular group of muscles to produce a maximal voluntary contraction in response to optimal motivation against an external load (20).
- Maximum Voluntary Strength – the maximum amount of strength that can be produced voluntarily without electrical augmentation. (Subcategories: Competitive and Training Maximum Strength) (22)
- Strength – the ability of a given muscle or group of muscles to generate muscular force under specific conditions (20); the ability of the neuromuscular system to produce force against an external resistance (22); ability to overcome or counteract external resistance by muscular effort (34).

FORCE AND VELOCITY

The variation of these definitions' challenges effective communication between the SCC, sport coaches, and researchers as each may be talking past one another instead of striving to understand the other's perspective (12, 31). The use of force in some of the definitions targets the kinetic variable that can be used as a unit of measurement in research, but from an applied perspective, SCC may use pounds (lbs.) or kilograms (kgs.) mass lifted. Force is reported in scientific manuscripts as Newtons (N) and measured by force platforms, which may or may not be cost effective, or time conducive with participants. Moreover, S&C programming usually takes a portion of their maximum amount of load lifted as guides during daily training sessions and is based on a repetition maximum (e.g. single or multiple) of an exercise (1, 22, 23). A key point when programming is that these percentages change from training either through adaptation or maladaptation depending on a multitude of variables (e.g. excessive psychological stress), which are beyond the scope of this article(1, 22). Additionally, the SCC can develop a percentage assignment based on

the type of exercise as it relates an exercise to its force-velocity (FV) properties as outlined by Haff and Nimphius (7). The question then becomes, "Would the use of FV to describe exercises be more appropriate for classification of exercises instead of the multiple strength definitions?" Most likely not, as the FV is applicable to kinetic and kinematic analysis while the simple definition by Siff (20) addresses that a strength exercise may have more or less force production. If the consideration of velocity (meters per second, m·s-1) is added, then at what point does the shift become a power exercise? The best guide for what would classify an exercise as a strength movement is anyone with a velocity (e.g., barbell or person) less than 1.40 m·s-1 (e.g., sumo deadlift) as values above (e.g., 1.70 m·s-1) would represent at cleans, snatch and other weightlifting variations (4, 8, 10, 21, 24).

The consideration of velocity in an exercise shifts it to a power movement which has been described as the ability to release maximum muscular force in the shortest possible time (23) or the quick application of force against resistance (1). The literal definition of power is the rate of doing work, that is equated by the amount of force exerted in a given distance over time, or the product of force and velocity (14, 22). The definition may be adequate in what type of performance is displayed during a sport or exercise, while the description of an athlete's physical quality or ability may be better directed to a non-sport science individual (e.g., athlete, exerciser) so they can understand the program's purpose (28). For example, describing to an athlete that their ability to jump higher and clean a greater load after 8-weeks of a S&C program is an improvement in power. There is a need for understanding that the best power definition is the one already established, while other descriptions by professionals only increases confusion of how power is expressed. Describing power to an athlete by using the term "explosive" works as a coaching cue but is a poor physical quality descriptor as explosive muscle strength (EMS) and rate of force development (RFD) share similar descriptions (7, 20, 32, 35). Measuring RFD via a force plate provides a quantitative unit of measurement (Newtons per second, N·s-1) so why is there a need for EMS to be used as RFD is part of an athletic power movement (7, 22). The RFD is a kinetic variable that can be obtained through force plates while the exercise classification is not needed as most weight training exercises that are used for developing strength will enhance RFD. For example, box squats have been demonstrated to have a high RFD production in comparison to powerlifting and traditional back squat techniques, while all other kinetic variables were similar (25). Therefore, all squatting styles can be applied if the plan's objective is to increase leg strength, possibly using the conjugate planning principle, but an increase to RFD would benefit from the specific use of box squats (25). This example provides context for clarity regarding exercise selection for physical quality or a specific biomechanical development.

COACHING AND PHYSICAL QUALITY TERMINOLOGY PERSPECTIVE

A sport's needs analysis can become complex if every variable is considered yet this could be simplified to observable sport performance variables that can be explained to athletes (Figure 1) (1, 23, 26, 29). Using nine categories for exercise selection allows for concise application within a program (Table 2) that relate to the performance of skills during a sport's competition (20, 22). The challenge is the amount or "how much" of each physical quality is needed in a sport requiring the SCC to select the appropriate exercise(s) and the application of the most effective intensities, volume, and rest (11, 23, 26, 28). For example, endurance in general is the time an activity can be sustained, absent of the energy systems to be developed (1, 20). Consider that every athlete needs some level of endurance but a marathon runner needs the endurance to run for a duration greater than an hour, while a basketball player needs the endurance to perform repeated high intensity skills with a short recovery of seconds during a quarter or half (1). Both athletes can use running but how it is performed can vary with the basketball player using accelerations interspersed with jogs that is more closely related to the sport (1, 19). An interesting point is that endurance training terminology has not seen the dozen descriptors as has been applied to resistance training (1, 20). For the most part, endurance has three goals predicated on bioenergetics with phosphagen, anaerobic, and aerobic (1). The question is, which energy system is needed most for success in the sport and one will always have the highest percentage followed by the others? Thus, terminology should have the category of endurance with the training methods applied to the development of the specific energy system. This principle applies to all programming terminology that will be used by a SCC, which is complicated when strength and power exercise selection is applied.

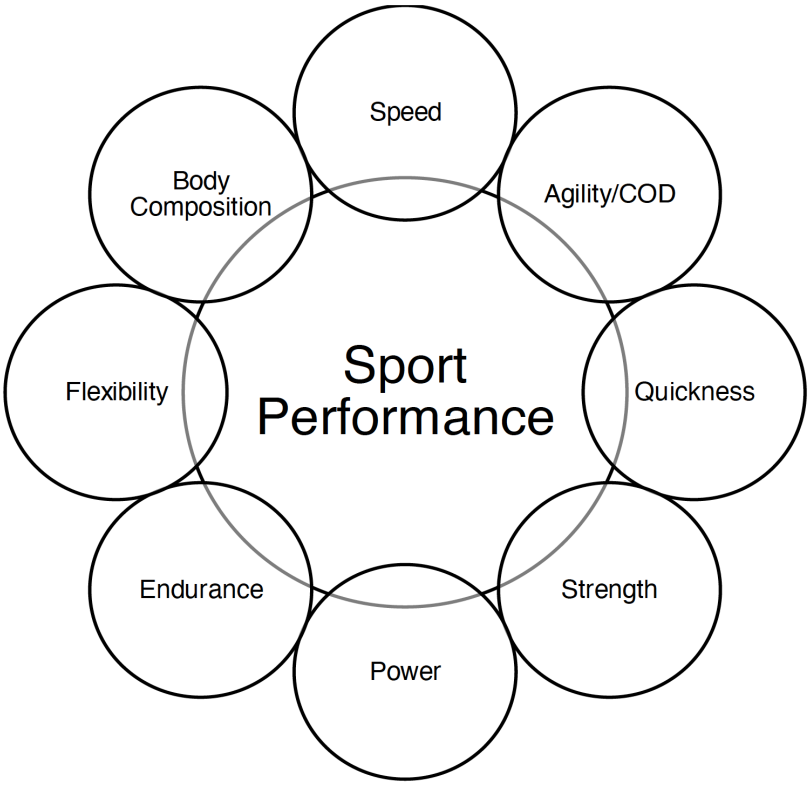

Figure 1. Sport Performance Variables

Table 2. Physical Qualities Definitions for Sport Performance

1. Strength – the ability of a given muscle or group of muscles to generate muscular force under specific conditions (20).
2. Speed – the ability to cover as distance quickly (1).
3. Agility – a rapid whole-body movement with change of velocity or direction in response to a stimulus (19).
4. Change of Direction (COD) – the ability to linear sprint, decelerate, and accelerate in an isolated component of agility in which the movement and perception are decoupled, and pre-planned (19, 33).
5. Quickness – a multi-planar or multidirectional skill that combines acceleration, explosiveness, and reactiveness (17)
6. Power – the optimal combination of speed and strength to produce movement (3).
7. Endurance – the ability of a person to perform activities continuously for a long duration or the ability to repetitively perform bouts of high-intensity exercise (1).
8. Flexibility – the range of motion of a joint or set of joints, dependent on the length of the muscles crossing the joints (1).
9. Body Composition – the relative proportions by weight of fat and lean tissue (16)

To begin with, a triangle of performance has been previously established in literature with each point emphasizing only three qualities of strength, speed, and endurance (1, 20). These points act as anchors for exercises with a continuum between them being Strength-speed, Speed-strength, Speed-endurance, Endurance-speed, Endurance-strength, and Strength-endurance (1,20). The lack of sport physical qualities such as agility, quickness, flexibility may relegate the strength-speed-endurance triangle to weight room-based training instead of overall exercise selection. One area of contention has been the addition of other descriptors between the terms to "explain" performance that only further complicates the discussion by adding terms not originally included in each angles continuum (1, 20). Terms already included in the performance triangle are sufficient as a movement may require more contribution from strength with less speed, barbell countermovement jump in comparison to bodyweight only countermovement jump. There is redundancy by adding terms (e.g., explosive strength) that are not needed because the continuum already addresses that specific quality. For example, as

the external load of a lift gets heavier more strength is needed to move it and speed will decrease due to the inverse nature (7).

Furthermore, is explosive an appropriate biomechanical term or should it be applied only to coaching cues, "Be explosive"? The consolidation of terminology in S&C for improving sports performance would be more effective if the categorization utilizes understandable and applicable terms that are already established in the professional literature with historical consistency. The application of other terms may be more appropriate when trying to quantify a specific kinetic or kinematic to a unit of measurement but care must be taken to avoid "paralysis by analysis".

BALANCING BIOMECHANICAL AND COACHING TERMINOLOGY

The use of kinetic or kinematic units of measurement (e.g. N·s-1, watts) provides coaches objective assessments for S&C plan effectiveness, monitoring, and progress (16). Although this method can prove to be beneficial, there may be a challenge when ambiguous, multiple definitions, or redefined terms are applied. For example, velocity-based training (VBT) can be an effective training method to improve athletic performance but the physical quality terms are more closely related to kinetic units of measurement while velocity (m·s-1) is a kinematic unit (6, 13). The argument or question is whether the categories of development are necessary (Absolute Strength, Accelerative Strength, Strength-speed, Speed-strength, Starting Strength) for improving athletic performance (6). All five use the term strength, the measuring of barbell velocity in this case is an observation of coordinating muscles contraction velocity being expressed during an exercise. The critique is not on the effectiveness of VBT, rather the redefining of terms to match velocity muddles how exercises are programmed. Absolute strength is the amount of weight that can be lifted for an exercise, while relative strength is the amount of weight lifted in relation to a person's body weight (34). Based on these definitions, absolute and relative strength are independent of velocity. As an alternative to these terms would be to classify VBT as an intensity measurement for strength exercises since its application has been used with barbell-based exercises. As previously stated, a barbell velocity will need to reach values above 1.50 m·s-1 to be considered power and by applying the work by Helms et al., (9) resistance training-specific rate of perceived exertion (RPERT) scale for intensity could be effective for programming weight room exercises. A terminology suggestion for using barbell velocity level for exercise selection instead of redefining established term could be very low (< 0.5 m/s), low (0.5 – 0.75 m/s), moderate (0.75 – 1.0 m/s), high (1.0 – 1.3 m/s), and very high (> 1.3 m/s) velocity (6). This terms use would remove the ambiguity of what "strength" quality is being trained and instead focus on the external velocity being displayed. The effectiveness of VBT as a monitoring and programming method is not being questioned (30) but S&C terminology consistency applicable to exercise selection is needed.

The irony is speed, agility, and quickness training have the least amount of terminology variances with linear maximum speed/velocity, acceleration, deceleration, agility, change of direction, and quickness (Table 2) (17, 19, 20, 33). Additionally, endurance training has been primarily based on duration of the sport, length of skills execution, and revolves around the bioenergetics of the ATP-PC, anaerobic glycolysis, and aerobic glycolysis systems (1). Based on these established dynamics endurance would logically have the subcategories of phosphagen, anaerobic, and aerobic focused. Other terms may not be necessary such as alactic, work capacity, short- and long-duration endurance, low- and high-intensity endurance, or stamina to describe programming for endurance (1, 16, 20). SCC may need to adjust terminology to a specific audience so they can make the purpose of their plan or program understandable creating "buy-in". This adjustment does not necessitate a need to add new definitions for the S&C profession, these terms or "cues" are being used to convey a point for improving athletic performance through a training program.

RATIONAL FOR CONCISE TERMINOLOGY IN PLANNING AND PROGRAMMING

The more terms or classifications that are used increases the chance of making plans and programs less effective as methods, exercise selection and order may be inappropriately applied, based on popular belief. The initial testing and needs analysis require the assessment of physical qualities specific to the success in sport performance (16). Thus, the terminology needs clarity of what is being assessed and not confused with the kinetic or kinematic variables measured. A point of confusion is that research needs to be narrow in the acquisition of

these variables while a physical quality will have contribution from multiple units of measurement (27, 31, 32) . For example, a vertical countermovement jump (VCMJ) is influenced by force, impulse, RFD, displacement, velocity, and power thus all of these may be measured (7). This obtainment of units of measurement does not require the application of a specific exercise for their enhancement rather what exercises or methods will have the greatest transfer of training effect (TTE) to sport performance. Consider the isometric mid-thigh pull (IMTP) is commonly used to measure lower body RFD (7) but does not necessarily translate well to overall physical quality development. The combination of hang power clean, hex bar deadlift, and step-up could have a more effective TTE than the IMTP, which could be retained for monitoring if the equipment is available. Planning and programming for developing an athlete's expression of power is needed to perform sport skills (32) that will either require more or less power to be successful. To provide context in this expression of power is a volleyball block requires enough power to displace the athlete high enough so their hands/arms can block a ball while the clean & jerk requires power to displace the external load of the barbell plus the body (1). The point is both will use weight training and jumps for power development (7) with the exception that a weightlifter will emphasize strength exercises (e.g., front squats) and externally loaded power exercises (e.g., cleans). Consider that Table 3 lists 17 different "strength" descriptions which may not be necessary as most exercises will develop physical qualities that overlap in the terms listed.

There is a point of contention when power is used as the literal perspective of power, if viewed in the true mechanical definition (12), complicates the

Table 3. Terminology used to describe exercise classifications or athlete's physical qualities.

Coaching	Exercise Science (Biomechanical and Bioenergetics)
1. Strength	1. Aerobic Capacity
2. Maximal Strength	2. Anaerobic Capacity
3. Absolute Strength	3. Anaerobic Power
4. Relative Strength	4. ATP-PC/Phosphogen
5. Accelerative Strength	5. Acceleration/Deceleration
6. Maximum Voluntary Strength	6. Force
7. Quasi-Isometric Strength	7. Impulse
8. Explosive-strength	8. Momentum
9. Power-Strength	9. Power
10. Low-speed muscular strength	10. Rate of Force Development
11. High-speed muscular strength	11. Speed
12. Reactive Strength	12. Velocity
13. Speed-Strength	
14. Strength-Speed	
15. Starting Strength	
16. Strength-Endurance	
17. Endurance-Strength	
18. Endurance	
19. Alactic	
20. Work capacity	
21. Stamina	
22. Short-duration Endurance	
23. Long-duration Endurance	
24. Low-intensity Endurance	
25. High-intensity Endurance	
26. Agility	
27. Non-linear Speed	
28. Linear Speed	
29. Quickness	
30. 1-step Quickness	
31. Change of direction	

progression of athletic performance development, as power is common vernacular in sports and S&C planning. As a SCC plans power development training phases, or blocks will need to determine the expression of power (1, 11, 20, 22). How the power is expressed in a specific sport dictate how the SCC will plan, program, and coach their athletes to improve their athletic performance. For example, is the power expressed as a softball player swinging a bat, basketball player completing a dunk, weightlifter performing a snatch, offensive lineman blocking, or a field athlete putting a shot. All of these would be considered power movements but attention placed on some are the displacement of an external load while the others is primarily body weight only (20, 29). As planning and programming progresses, DeFilippo (5) suggests that combining a strength base with the ability to accelerate is power, which results from the application of weight training (strength) and fast movements (e.g., power – cleans, jumps). Based on this training suggestion, athletes should incorporate exercises like hex bar squat jumps, power cleans, bounds, depth jumps, or split jerks that have the expression of high forces with increasing muscle contraction velocity that can continue over into competitive performance (7). Although there are multiple descriptors of power and strength combinations in exercise classification these just adds to "paralysis by analysis", as power is an understandable description that can be explained to those that do not have education in exercise/ sport science. Knudson (12) states, "Strength and conditioning research should limit the use of the term power to the true mechanical definition and provide several specific and measurement details on this measurement." Although this comment has biomechanical validity there is a lack of specific and consistent terminology between SCC, researchers, and sport coaches on the use of the term power. Moreover, Winter et al., (31) suggest the use of the term "critical intensity" for sport science stating, "Universal adoption of intensity will help reduce the confusion and perpetuation of erroneous understanding of mechanical work, energy, and power in sport and exercise. Importantly, adoption of this recommendation by journal editorial teams will help advance sport and exercise science." These are interesting professional discussion topics though there needs to be consideration of what terminology is understandable by athletes, coaches, sports medicine, and sport scientists instead of adding philosophical debates. For instance, the numerous strength derivatives based on previous literature (Table 1) presents the complexity to exercise selection during programming and how can each derivative be explained to an athlete. During the application of a program, athletes will need to have some level of understanding of why they are performing an exercise to potentially improve motivation or "buy-in". The planning of physical quality development should be based on its contribution to sport performance (Figure 2) using understandable and consistent terminology.

PRACTICAL APPLICATION

All professions reach a point that a decision needs to be made on consistency with terminology that should be based on its applicability and understanding to those who will be the most effected (e.g. athletes, clients, patients). The planning, programming, and coaching of exercises should be classified based on a physical quality description while the exact units of measurements should be reserved to specific biomechanical and bioenergetic terms. Caution should be used when companies, training devices, technology, or training programs start modifying terms to promote a specific product that contributes to professional confusion. SCC should consider the amount the expression of the qualities (Figure 3a-d) instead of adding multiple terms that has overlapping meanings. If the majority of the terms currently used in S&C were placed in a planning hierarchy it would create a large number of categories to select exercises (Figure 4). The placement of the terms is subject to interpretation and is placed as close as possible based on the available conflicting terminology. The steps to grow the S&C profession have been positive but the confusion, misunderstanding, and miscommunication in literature, podcast, social media, and presentations because of the various terminology used restricts the ability to provide the most effective programs due to the paralysis.

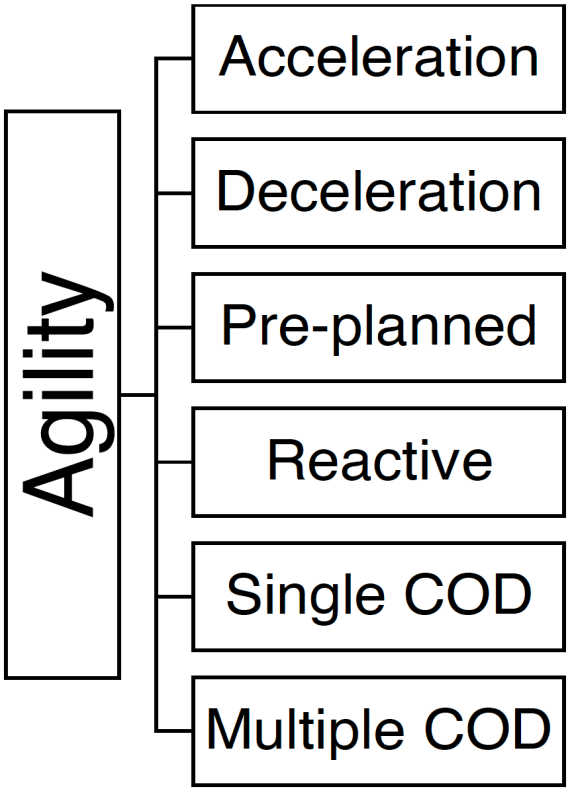

Figure 3a. Agility Hierarchy

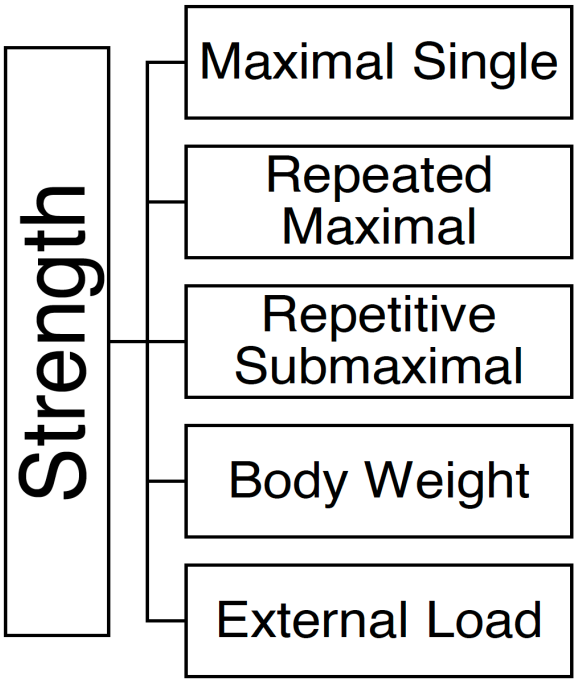

Figure 3b. Strength Hierarchy

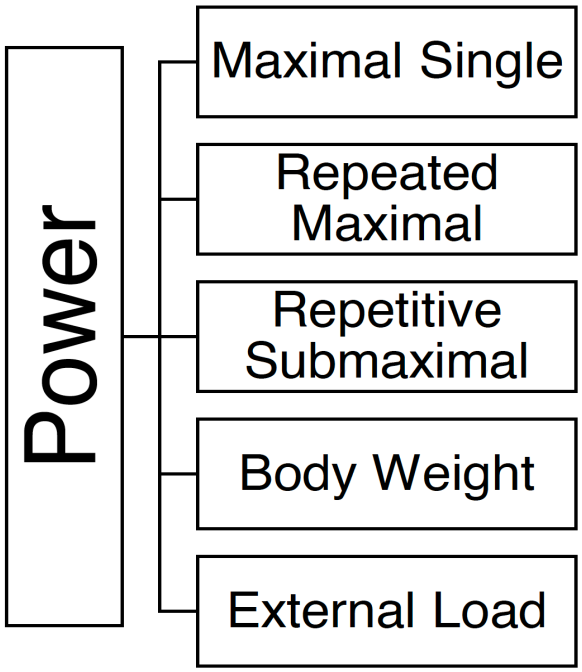

Figure 3c. Power Hierarchy

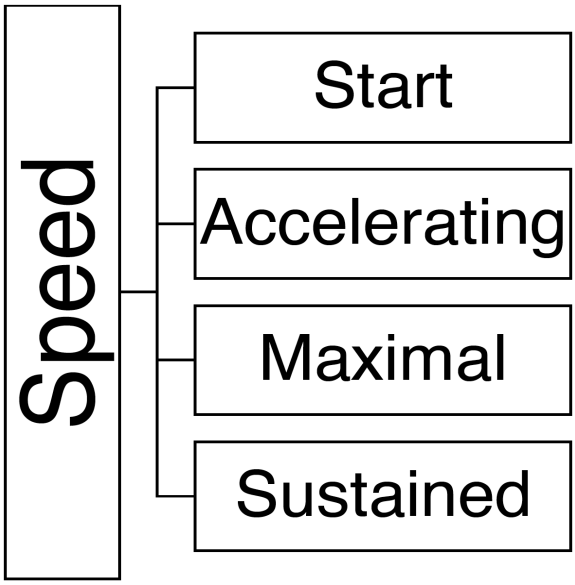

Figure 3d. Speed Hierarchy

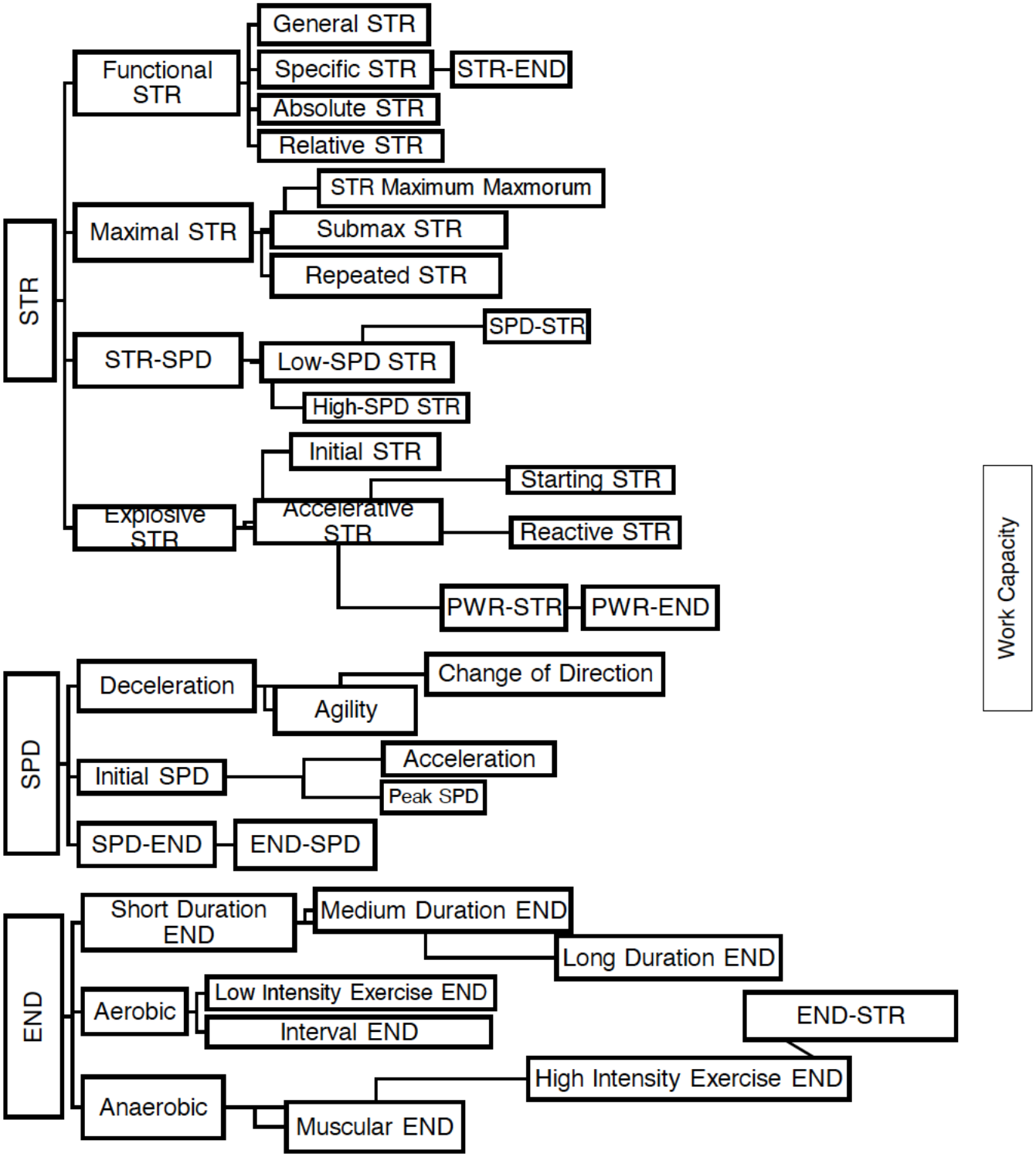

Figure 4. Hierarchy Example of Current S&C Terminology. Endurance (END), Power (PWR), Speed (SPD), Strength (STR)

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