Session No. 761

Rules of Thumb and Safety Truisms

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Introduction

There are many "rules of thumb" and sayings that are used in the safety field. While the end result of applying these "rules" can sometimes be beneficial, many are not strictly true and may result in confusion, less than optimal performance, or worse. For example, "a load held away from the body is 7-10 times 'heavier' than one held close to the body." This guidance may result in some employees reaching less while lifting, but it is an exaggeration and simplification. Other guidance, such as "lift with your knees, not with your back," may not result in optimal lifting for a number of reasons. Others quote statistics such as "the indirect cost of an accident is 3-5 times the direct costs." While this may be true in some circumstances, perhaps even conservative, is there a "universal" ratio of indirect to direct costs? This paper addresses some rules of thumb and "answers" whether a rule is effective or not. The paper contains references and example calculations to support conclusions regarding each "truism" evaluated.

<u>Truism: A Load Held "Away" from the Body Is 7-10 Times "Heavier" Than One Held Close to the Body</u>
This "truism" is of course not literally true, since the object weight is the same regardless of where it is held. However, when considering the "intent" of this guidance, the muscular effort and resulting forces on the body do change with the position of the object. Consider the following object: a box of tools that weighs approximately 36 pounds. We will focus on the resulting compressive force in the subject's low back (back compressive force or BCF). In each image, the subject progressively holds the load further from the body (Figure 1).

Figure 1. Demonstration of Back Compressive Force on Man Holding Toolbox at Various Distances from Body

BCF = 353 lbs	BCF = 383 lbs	BCF = 528 lbs
SMOM = 226 in-lbs	SMOM = 289 in-lbs	SMOM = 447 in-lbs

As the load is progressively held away from the body in this upright posture, back compressive force (BCF) increases by a factor of about 1.5, while the moment at the shoulder approximately doubled as the load was moved forward. BCFs were computed using the University of Michigan 3-D Static Strength Prediction Program (3DSSPP) (University of Michigan, 2008). Shoulder moments (SMOM) were computed in inch-pounds by the authors, using the object weight and estimates of the subject's body segment weights (Chaffin et al, 1999).

Suppose the subject was leaning forward while lifting this box of tools. The following BCFs and SMOMs were computed for a subject that was bent at approximately 30˚ from vertical (Figure 2).

Figure 2. Man Leaning Forward While Lifting Box.

BCF = 504 lbs	BCF = 702 lbs	BCF = 806 lbs
SMOM = 77 in-lbs	SMOM = 239 in-lbs	SMOM = 405 in-lbs

This time, the back compressive force increased by 1.6 times, and the shoulder moment increased by about 5.3 times. This more dramatic increase in shoulder moment was achieved because the load in the picture at left could be brought closer to the shoulder (therefore decreasing the moment significantly). Repeating the above experiments with a small 2-pound box had the following results (Figure 3):

Figure 3. Man Holding 2-lb Box, with Arms at Various Distances from Body.

BCF = 124 lbs	BCF = 170 lbs	BCF = 193 lbs
SMOM = 33 in-lbs	SMOM = 69 in-lbs	SMOM = 87 in-lbs

BCF increased 1.6 times and shoulder moment more than doubled (2.6 times greater). Repeating the 30˚ bend trial using the small object saw a modest increase in BCF (1.3 times as much), but a large jump in shoulder moment (13.5 times as much). It should be noted, however, that 81 in-lbs is still a relatively modest overall shoulder moment (Figure 4).

Figure 4, Man Leaning Forward While Holding 2-lb Box at Various Distances from Body.

BCF = 356 lbs	BCF = 378 lbs	BCF = 465 lbs
SMOM = 6 in-lbs	SMOM = 44 in-lbs	SMOM = 81 in-lbs

The amount of increase to expect from holding loads away from the body is a function of the subject's posture and the weight of the object held. While it is possible to increase the load 7-10 times by holding it away from the body, this is only possible with relatively light objects and/or while in poor trunk postures. How a load "feels" is a matter of psycho-physics and is not addressed here. However, holding the heavy tools away from the body did "feel" many times harder. As a rule of thumb, this guidance is useful and could help to promote better lifting and manual material handling postures. Perhaps a revision to "A load held away from the body is typically 2-5 times 'more difficult' to lift than one held close to the body" would be more appropriate.

Truism: 90% of Accidents Are Caused by "Unsafe" Acts

Much has been said about this assertion, which originates with the work of H. W. Henrich. In fact, many behavior-based safety programs are predicated on this concept. There is an attractive simplicity to this statement, as it implies that 90% of accidents can be eliminated by altering the behavior of employees. However, this over-simplified statement can be argued to have a done as much harm as good. For a more complete discussion of this “truism,” please refer to Fred Manuele’s book, *Heinrich Revisited: Truisms or Myths* (2002). Heinrich classified accidents into three categories and found the following relative contributions: (1) 88% of accidents are caused by unsafe acts of persons; (2) 10 percent are caused by unsafe mechanical or physical conditions; and (3) 2 percent of accidents are unpreventable. Without addressing whether or not 2 percent are truly “unpreventable,” we will simply address the arbitrary classification into “acts” vs. “conditions.”

Accidents are multi-factorial and cannot be simply divided into such “either-or” categories. For example, consider the following scenario. A man is late for a safety meeting. He runs down the hall and spills some coffee on the floor. He does not stop to clean it up. A second man walks by on his way to the meeting, but does not stop to clean up the coffee, since he wants to be on time to the safety meeting. A third man is running down the hall to the same meeting and slips on the coffee, breaking his hip. Is this an unsafe action or condition that “caused” the broken hip? The coffee on the floor is an unsafe condition, spilling it was an unsafe action. Running is an unsafe action. Is failing to clean the coffee an unsafe action? Is missing a safety meeting to clean up coffee an unsafe action? Whose unsafe action is *the* cause of this accident? Would this accident have occurred without the unsafe condition of the coffee on the floor? Does this simplistic analysis avoid getting to the root causes of this accident? For example, why are people running to this meeting? What steps should be taken to prevent such an accident in the future?

The authors consider a dichotomous conclusion (condition *or* act) based on the work of Heinrich to be counter-productive to proper accident investigation and argue that *both* unsafe actions and unsafe conditions are present in most accident scenarios. It is important to study the environment when investigating accidents. Environment goes beyond the physical environment and includes the safety culture and management structure of a firm and how this environment can encourage/discourage unsafe actions while simultaneously addressing physical hazards and incorporating means for minimizing both the probability and the effects of accidents should they occur.

<u>Truism: Indirect Costs Are 3-5 Times the Direct Costs of Accidents</u>

This truism is intended to convey the overall impact of accidents beyond the direct/obvious costs (such as medical costs). Indirect costs include costs associated with investigating accidents, replacing workers, paying overtime, loss of productivity, impact to morale that can affect quality, snd do forth. This is often used as “ammunition” to convince management that a particular safety expenditure should be made and to “rally the troops” behind the importance of safety. But is this ratio accurate?

This ratio has been studied and there is no *single* ratio for all circumstances. For example, suppose that a worker requires a first aid treatment such as a bandage applied by an EMT on duty at a facility. While the worker receives care and is treated, assume that his or her machine is shut down and not producing parts, which may impact downstream processes, particularly in a “lean” work environment. In this case, the indirect costs of lost productivity would likely be many times the cost to apply the bandage to the employee. In more severe injury cases, it is possible for the indirect costs to be closer to the direct costs themselves. In fact, lower severity injuries typically cost more (in terms of ratio of indirect to direct costs) than more severe, lost-time injuries (Manuele, 2002).

The authors recommend that safety professionals research indirect costs in detail for a sampling of jobs at their facility based on historical data. These data can provide indirect to direct ratios as functions of the type and severity of accident. In this way, they can relate the impact of accidents to management in a way that is much more convincing than simply quoting the 3-5 ratio. In some instances, it may actually be much higher and could be used help motivate positive safety changes.

Truism: To Properly Position a Ladder Against a Wall at a 4-1 Ratio, Put the Base of the Ladder at Your Toes and Extend Your Arms Directly in Front of Your Body While Gripping the Side Rails. Resulting in the Proper Angle

To evaluate this truism, a ladder was positioned by the authors several times at several different lengths. (*Note:* The ladder length should not matter since the angle is determined by the body dimensions or anthropometry of the user.) Positioning the ladder in this manner resulted in a ratio of 3.9 for both authors and was quick and easy to do. Folding the ladder to 9- and 6-foot lengths resulted in ratios of 3.7 and 3.8, respectively.

Figure 5. Positioning of Ladder at Proper Distance for 4-1 Ratio

In order to predict the usefulness of this for the general population, the relative proportions of various body segment lengths were used to estimate the angle that would result for “averagely” proportioned individuals. Using such proportional data (Drillis et al, 1964), an expected ratio of approximately 3.6 was found (depending on the types of shoes worn by the subjects placing ladders). A thicker toe, such as on a safety shoe, would actually improve the performance of this rule of thumb slightly. This appears to a good rule of thumb for initial placement of the ladder, which can then be “fine tuned” using more precise alignment methods, such as the “L” stickers commonly found on ladders, including the one pictured here.

Truism: If You Must Be Within Arms’ Reach to Hear “Normal” Conversation, You Are Exposed to Noise at Or Above 90 dBA

In order evaluate this truism, a recording of a vacuum cleaner was played back at 90 dBA, as measured in the hearing zone of the authors. The authors alternated in roles as “speaker” and “listener” (eyes closed). The listener extended his arm, while the speaker moved slowly towards him. The listener indicated when he could understand, not just hear the speaker. This did not occur for each author until the speaker was at arms' length or less. While this truism does not indicate the actual level of noise, is a good indication that the noise level is likely excessive.

Figure 6. Demonstration of Hearing with Nose Level Above 90dBA

Conclusion

Many rules of thumb, like the preceding noise example, are useful and can be employed by safety professionals to help workers maintain a safe and healthy workplace. Others, however, can be misleading or even counterproductive. Safety professionals should take care to fully understand how employees might use or misuse such truisms. Demonstrating some truisms such as the noise and ladder examples as part of "hands-on" training could also be beneficial for employees and the limitations of the truisms could be discussed.

References

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