

# **Ergonomic Analysis Comparison of the VITEK® 2 and VITEK® 2 Compact with the Microscan WalkAway® 96 and Phoenix™ For Work Flow Efficiency and the Likelihood of Distal Upper Extremity Strain**

By

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Using ergonomic analysis, the set up processes were compared for four automated microbial identification and antibiotic susceptibility systems (ID/AST), the VITEK® 2, VITEK® 2 Compact, (bioMérieux, Marcy l'Etoile, France), Microscan WalkAway® 96, (Siemens, Deerfield, Illinois, USA) and Phoenix™, (Becton Dickinson, Sparks, Maryland, USA) to assess the physical strain caused to the technologist's forearms, wrists and hands, measured with the "Strain Index". The Strain Index (SI) is a tool used by Ergonomists to evaluate repetitive and exertional demands of a task and predict increased risk of distal upper extremity strain to end-users. In addition, the analysis also included a comparison of the number of steps in card or panel set-up and work cycle time. This study is intended to identify if efficiencies in card or panel set up will also minimize the likelihood of strain to the forearms, wrists and hands of laboratory scientists using the instruments thereby reducing the risk of musculoskeletal injuries. Results indicate that the set-up processes for VITEK® 2 and VITEK® 2 Compact were found to have a lower strain index and shorter work cycle times than the other systems resulting in a likelihood of reduced risk of musculoskeletal injury.

## **INTRODUCTION**

Hospital and biotechnology laboratories are finding themselves facing the same ergonomic risk factors and problems found typically in office and assembly manufacturing facilities; i.e. the threat of Cumulative Trauma Disorders (CTD) and Repetitive Motion Injuries (RMI). This includes soft tissue injuries such as tendonitis of the shoulder, elbow, wrist or hand along with nerve compression injuries like Carpal Tunnel Syndrome. The Bureau of Labor Statistics (BLS) in the annual report of non-fatal occupational injuries and illnesses does not clearly track and differentiate work injury statistics for clinical laboratory workers.<sup>1</sup> As a result; it is difficult to know the extent of CTDs and RMIs in the laboratory. These work-related injuries not only result in personal pain and decreased productivity for the technologist but also a financial impact for the employer.

Increasingly, more tasks are automated in the laboratory but not all risks for distal upper extremity strain have been eliminated. The primary risk appears to be excessive repeated movement patterns combined with awkward postures and forceful manual exertions. Much of this is the result of increased work volume, staff cutbacks, limited task tolerance for an aging workforce and inadequate design of today's laboratory facilities, instruments and hand tools. Frequency of repetition is a common driver in many of these CTD injury cases. In many laboratories, the work volume has drastically increased above and beyond what a technologist performed many years ago when work was primarily manual and not geared towards high volume analysis. Research in the last 15 years, describes significant risk of injury to technologists that perform traditional pipetting in the laboratory.<sup>2,3,4</sup>

With this in mind, it should be an essential business objective for today's laboratory managers to choose devices that can assist scientists with improved work processes and work flow to reduce the likelihood of CTDs and RMIs and at the same time provide quality diagnostic results. One example is ID/AST testing. The main systems for ID/AST testing include the VITEK® 2 (V2), VITEK® 2 Compact (V2C), Microscan WalkAway® 96 (WA), and Phoenix™ (PHX). Each requires participation by laboratory scientists to prepare the samples, load the instruments and monitor them for results.

The purpose of this study was to evaluate and compare the ergonomics and safety of each system by using a specialized test called the "Strain Index" (SI) to determine the exertional demands of the work cycle and predict whether there is an increased risk of distal upper extremity strain to end-users. Additionally, the number of steps required for card or panel set-up and work cycle time were evaluated for each system.

## **Materials and Methods**

The study involved 19 clinical laboratory scientists (CLS) and 4 laboratory assistants (LA), from different facilities, to compare the identification (ID) and susceptibility (AST) testing systems regarding the number of steps to perform the card or panel set-up for each system and the time to complete one work cycle.

The data collection included a detailed time and motion study of the typical set-up routine for the V2, V2C, WA, and PHX work cycles. This included an onsite analysis of how the systems were used with specific attention to the cycle time to complete the routine ID/AST task during the study period. Digital photos and video were taken of each user performing the panel or card set up for each system. The video was then analyzed for the number of steps performed in each set up and the time to perform one complete work cycle. The work cycles were broken down into each component to allow comparison between the instruments to determine efficiency relative to the actual number of steps to perform each work cycle.

The data was then applied to the SI to determine if the typical work cycle for each instrument was safe or hazardous as it pertains to developing a musculoskeletal disorder from a hand-intensive task. The SI is an ergonomic assessment tool that has been developed and validated by Moore, et al.<sup>5</sup> The index is used to assess the relative risk of developing a distal upper extremity strain often occurring with selected manual tasks. The analyst evaluates six task variables related to intensity, exertion, duration and posture as listed in Table 1. The task variable is given a value called a multiplier. The product of the six task variable multipliers produces a number called the SI score. This score is compared to a gradient that identifies the level of risk for that particular task. Moore states in his research that an SI score of 5 or less indicates the least likelihood of strain and that an SI score of less than or equal to 3 is “almost always safe” while an SI score of greater than or equal to 7 is “almost surely hazardous”.

**Table 1. Strain Index Task Variables relative to ID/AST work cycle.**

Task Variable	Purpose	Relevance to ID/AST Cycle
<b>1. Intensity of Exertion</b>	Perceived effort; % of maximum strength from barely noticeable to uses shoulder or trunk to generate force.	Perception of effort needed to uncap or unscrew test tubes, standardize the bacterial suspension, open packages and cards.
<b>2. Duration of Exertion (% of cycle)</b>	100 x duration of all exertions (sec)/total observation time (sec).	% of time required to pinch/grip test tubes, cards and plates compared to entire cycle.
<b>3. Hand/wrist posture</b>	Neutral to near extreme.	Position of the wrist/hands during cycle.
<b>4. Efforts per minute</b>	Number of exertions/total observation time (minutes).	Counting the number of pinch/grip times required to unscrew, uncap or push pipette plunger.
<b>5. Speed of work</b>	Perceived speed from relaxed to barely able to keep up.	Perception of the time it takes to perform the work cycle.
<b>6. Duration per day</b>	Length of time of task from < 1 hour to >8 hours.	Total cumulative time the task is performed throughout the day.

## Results

### *Work Cycle of ID/AST systems:*

Observations of each scientist took place to document the work cycle for each of the ID/AST systems. In some cases, the scientist’s work routines varied slightly from the manufacturer’s recommendations. The table below summarizes the average number of steps in the set-up of the ID/AST cards or panels for one bacterial isolate, the average time to complete the work cycle and the typical work cycle routine observed. Cumulative results for both CLS and LA performing the set-up are provided for the V2, V2C, WA, and PHX. Scientists demonstrate some individual variation in the preparation of cards, panels and plates but in general, the same tasks are performed with slight differences in the task routine. Since all systems included preparation steps for gathering and opening supplies, data entry, and streaking a purity plate, these steps were not include in the timing portion of the study.

**Table 2. Results of Ergonomic Analysis comparing set up steps and work cycle time performed by the Clinical Lab Scientists (CLS) and Laboratory Assistant (LA) for one ID/AST test.**

	VITEK 2	VITEK 2 Compact	BD Phoenix	MS96
<b>#CLS/LA Observed</b>	11 CLS, 0 LA	3 CLS, 0 LA	3 CLS, 0 LA	2 CLS, 4 LA
<b>Average # steps in set- up</b>	9	11	18	21
<b>Average time to complete a work cycle</b>	60 seconds	64 seconds	72 seconds	90 seconds
<b>Typical Work Cycle Routine Observed</b> <i>(Note: Observations of scientist’s routine may vary slightly from the manufacturer’s recommendations.)</i>	1. Scan accession ID 2. Select colony 3. Dilute in test tube 4. Measure suspension in DENSICHEK™ 5. Load test tube in Cassette. 6. Scan plate and card.	1. Scan accession ID 2. Select colony 3. Dilute in test tube 4. Measure suspension in DENSICHEK™ 5. Load test tube into Cassette 6. Pipette from ID tube	1. Select Colony 2. Unscrew test tube cap 3. Dilute in test tube 4. Screw test tube cap on 5. Vortex test tube 6. Measure suspension	1. ID plate and bottle 2. Break open bottle 3. Pick colony 4. Pull off end of wand. 5. Inoculate

7. Load card in Cassette	to AST tube	in Phoenix Spec	Prompt bottle
8. Data entry*	7. Scan ID Card	7. Place test tube in panel platform	6. Close Prompt bottle
9. Load Cassette into instrument	8. Place ID card into test tube	8. Unscrew cap on ID test tube	7. Shake Prompt bottle
	9. Scan AST card	9. Unscrew cap on AST test tube	8. Peel label off Prompt bottle
<i>*repeat step 1-8 for up to 7 ID/AST tests.</i>	10. Place AST card into test tube*	10. Add 1 drop AST indicator to AST tube	9. Place label on panel
	11. Load Cassette into instrument	11. Pipette from ID to AST tube	10. Break prompt bottle seal
	<i>*repeat steps 1-10 for up to 5 ID/AST tests.</i>	12. Pour ID suspension into panels	11. Streak plate
		13. Recap AST tube.	12. Pour suspension into Renok tray
		14. Mix AST suspension	13. Cover tray
		15. Pour AST suspension into panel	14. Pile purity plates into can and label
		16. Snap caps into panel	15. Place Renok over tray to draw liquid
		17. Scan panel	16. Transfer to ID/AST combo panel
		18. Load all panels one at a time into instrument	17. Collect waste trays and discard
			18. Add oil to ID panel
			19. Cover and stack panels.
			20. Label panels.
			21. Load into incubator
			<i>*8-21 performed by LA</i>

*Ergonomic Risk Factor Exposures:*

In this study, the use of ID/AST systems is noted as a repetitive process that varies with the actual number of patient samples that need to be tested.

- The frequency of repetitive motion for the V2 and V2C demonstrates that each action is performed independent of the next over the one minute period in which the cycle occurs unlike the other systems that require more frequent repetition within the cycle time. The exception is noted when dilution of the colony in the test tube is repeated more than once in order to obtain the correct McFarland result. When this process is repeated, it is repeated within a minute interval but is generally not repeated for another minute or more.
- PHX involves significant repetition with pipette use and capping of the panels.
- WA process requires a highly repetitive work cycle of opening the Prompt bottles at least one time every ten to thirty seconds making it the most repetitive of the four instruments.
- Observations consistent with using the ID/AST systems also reveal commonly repeated awkward postures and forces that are often associated with developing a musculoskeletal disorder. These include:
  - Repeated pinching with the thumb and index finger to grasp the cotton swab, test tube or Prompt bottle
  - Pinching with wrist deviation combined with excessive wrist bending up or down.
  - Sustained downward neck bending, arm reaching overhead combined with head/neck bending upwards to look at test tube turbidity over-head.
  - Prolonged standing
  - Forceful exertions to the hands include pipette plunger activation with the thumb, snapping caps on panels with the fingers and thumb, screwing/unscrewing test tubes, grasping the Renok tool, opening bottles and tearing foil packaging.

### Strain Index Results

In reference to the documented work cycles, data was calculated using intensity of exertion, duration of exertion within each cycle, hand wrist postures, efforts per minute, speed of work and duration of the task per day to determine the relative risk of strain to scientists using the selected ID/AST systems. Results were then averaged for all work cycles observed for each instrument and applied to the Strain Index. Results are broken down by time of use from zero to one hour, one to two hours, or two to four hours per day. Desirable scores are those that are 5 or less indicating the least likelihood of strain. A score of less than or equal to 3 is “almost always safe” while a score of greater than or equal to 7 is “almost surely hazardous”. Table 3 details the Strain Index scores for the four systems.

**Table 3. Strain Index Scores for the four ID/AST systems**

	VITEK® 2	VITEK® 2 Compact	BD Phoenix™	Microscan Walkaway®
<b>Average Strain Index Score:</b>	SI	SI	SI	SI
<b>0-1 hour use</b>	2.25	.75	7.5	Not assessed
<b>1-2 hours use</b>	4.5	2.25	26.5	6.75 (CLS portion)
<b>2-4 hours use</b>	6.75	Not assessed	Not assessed	60.75(LA portion)

### Discussion

The SI score indicates a low risk for a musculoskeletal disorder to the elbow, forearm, wrist and hands when performing the V2 and V2C set-up sequence for up to two hours per day and possibly up to four hours/day. It was noted that employees who work in an organized manner, take their time, use minimal force through the task and have minimal problems preparing the suspension measurement experienced lower SI Scores. SI scores were noted to increase with the following conditions regardless of the ID/AST system used:

- Adjusting the McFarland suspension increased cycle time 30%-50% of the total task cycle.
- Perceiving “an obvious effort” of exertion to perform the task rather than a “barely noticeable” effort or “definite” effort
- Increasing duration of more than 2 hours per day.
- Demonstrating postural deviations of awkward hand manipulations to achieve the correct dilution with the swab, neck extension and shoulder flexion above shoulder height to head height, reaching around and over equipment or failing to unwrap or prepare cards and swabs ahead of time for easy retrieval.

Based on the (SI) alone, scientists using the PHX and WA were at a significantly higher risk of strain even with one hour of use. The increased SI score for the PHX system is attributed to excessive intensity and duration of exertion with capping, uncapping and pipetting as well as the wrist/hand postures observed. Scores for the WA system set-up was more of a risk for the LA compared to the CLS since the LA performed all WA panel set-up steps with the Renok tool, requiring significant manual forceful exertion and repetition for a duration of more than two hours a day.

The V2 and V2C work processes are significantly more efficient in the number of steps required to set up the test cards prior to placing them into the instrument. Results demonstrate 40-50% fewer steps compared to the PHX and WA. This efficiency is also reflected in the average time to complete a typical work cycle showing an average productivity savings of 8 to 30 seconds per cycle or 12%-30% using the V2 and V2C. Finally, the risk of straining the distal upper extremities, including the wrist and hands is substantially higher for the PHX and the WA, especially if use exceeds one or more cumulative hours of repeated work cycles in a typical work day. Lower SI scores can be attributed to a number of variables such as scientist’s perception of the task intensity of exertion, speed of work and the length of time the task is performed over the day. In this study, scientists’ perception of the work effort using the V2 and V2C were easier than the other systems contributing to lower SI scores.

### Conclusion

The use of advanced technologies in the laboratory for diagnostic purposes is a vital part of today’s healthcare industry. Identifying instruments that are designed to achieve accurate results for diagnostic purposes lessening time for scientists to perform testing while also minimizing the exposure to musculoskeletal disorders for users is of critical importance to hospitals, laboratories and clinical facilities around the world. This study has identified how the use of ergonomic analysis can assist laboratory managers in choosing instruments that not only support quality diagnostics but also reduce the risk of cumulative trauma and repetitive motion injuries to scientists. The results indicate that the V2 and V2C offer more efficient work cycles with less exposure to ergonomic risk factors resulting in a reduced risk of injury to laboratory staff.

## References

1. Bureau of Labor Statistics, 1996-2002, *Characteristics of Injuries and Illnesses Resulting in Absences from Work*, BLS, Internet, [www.bls.gov](http://www.bls.gov) .
2. Bjorksten, M.G., Almby, B., Jansson, E.S., (1994). Hand and shoulder ailments among laboratory technicians using modern plunger-operated pipettes. *Applied Ergonomics*, 25, 88-94.
3. Bjorksten, M.G., and Jonsson, B.(1977). Endurance limit of force in long term intermittent static contractions. *Scandinavian Journal of Work, Environment and Health*, 3, 23-27.
4. David, G. and Buckle, P. (1997). A questionnaire survey of the ergonomic problems associated with pipettes and their usage with specific references to work-related upper limb disorders. *Applied Ergonomics*, 28, 257-262.
5. Moore, Steven J., Garg, Arun, 1995, "The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders", *American Industrial Hygiene Association Journal*, 56: 443-458.