Industrial Athlete: Implementation and Effectiveness of a Multifaceted Program for the Prevention of Occupational Injury

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Abstract – In this paper we describe the effectiveness of the Industrial Athlete program that has been in effect since 2005 in the Puget Sound area. This voluntary program started with the goal of reducing workplace injuries by improving physical resilience and eliminating the pain and discomfort that often results from performing a physically demanding job. Data have been collected and analyzed since the inception of the program. Multiple analytic techniques have been used to assess the effectiveness of the program given the challenges of implementing and sustaining the program in a dynamic manufacturing environment. This paper highlights some of those results by showing the analysis of the Job Conditioning and the Symptom Intervention components of the program. We show the challenges of data analysis for such a program, but also demonstrate how the data can be used to show the effectiveness of both Job Conditioning and Symptom Intervention.


I. INTRODUCTION

Starting in late 2004, The Boeing Company – and in particular, Boeing Health Services – introduced the “Boeing Industrial Athlete (IA) Program” - a multi-faceted physical conditioning program based on utilization of sports medicine techniques in the industrial setting. The initial program was designed by Dr. Deborah R. Smith and relied on benchmarking of a program implemented by another global original equipment manufacturer. The program was implemented initially in Everett by Corinne Towler and in Renton by Catherine Curley. As the program expanded, other program managers came on board and currently the program is offered at various sites within Puget Sound and Salt Lake City, with a pilot in Philadelphia and plans for expansion to additional locations in 2015. Corinne Towler is the Senior Manager for Industrial Athlete; Catherine Curley, Tina Hermans and Karen Rogers are the program managers at different sites.

Like professional athletes training for competition, the Boeing IA program takes aim at eliminating discomfort and pain that often results from performing a physically demanding job and improving physical resilience of the employees. The primary purposes of the Boeing Industrial Athlete program are: 1) improve the overall physical resilience of Boeing employees to prevent the occurrence of occupational injuries and work-related time loss (Job Conditioning); 2) detect and treat early symptoms before they resulted in an injury (Symptom Intervention); and 3) return injured employees to the workplace earlier than might otherwise be expected using traditional return-to-work methods (Work Hardening). The Job Conditioning component was further broken down into two different offerings: one for new hires (New Job Conditioning), and another for existing employees (Job Conditioning). A description of the Industrial Athlete program was published by Case (2005) in Boeing Frontiers magazine.

The Industrial Athlete program was initially introduced in early 2005 at the Everett Site and targeted “high injury risk” employee populations (see “Target Population” below). Not all of the program components were initiated or available at the same time, and refinement and improvement of the various components of the program were ongoing. The program expanded to the Renton Site in January 2006 and in the Auburn and Frederickson sites in June 2007.

At the time of benchmarking in 2004, the other OEM reported a 63% reduction in injury post-implementation of...
their Work Conditioning program (comparable to Boeing’s New Job Conditioning), and reported 80% of participants in their Early Symptom Intervention program did not progress to recordable injury. The outcomes were shared verbally with Boeing without documentation, and were not substantiated by published studies in peer-reviewed literature. The OEM’s outcomes for Work Conditioning are similar to early IA Job Conditioning studies, utilizing limited numbers of participants. The Early Symptom Intervention programs are similar between the benchmarked OEM and Boeing, in that they both focus on body mechanics and work methods, however Boeing added manual intervention elements to the Symptom Intervention program (Athletic Training and Deep Tissue Intervention).

We decided before the start of the program to collect data and use the data to evaluate the effectiveness of this program. In the remaining sections, we will discuss the target population, the data collected on the program, analytical methods used to decide the efficacy of the program and the results from our analysis. Many of the analyses in this report were performed using the SAS software, version 9.

In section II of the paper we discuss the IA program implementation including the different elements of the program. In section III we discuss results on IA program utilization. In section IV we detail the analysis of the data collected for the program and finally in section V we summarize the conclusions from the analysis.

II. PROGRAM IMPLEMENTATION

Because resources with which to implement the Industrial Athlete program were limited, the program was confined to manufacturing organizations in the Puget Sound region, where most of the company’s highest injury risk manufacturing operations took place. Participation was further limited to Boeing Commercial Airplanes (BCA) employees, as BCA was the primary sponsor of the program. Participation in the program was on a voluntary basis.

Implementation of certain aspects of the Industrial Athlete program, such as Job Conditioning classes, was determined by the availability and capacity of the IA staff and manufacturing considerations. For example, the limited number of Industrial Athlete personnel meant that only a few classes could be offered concurrently, and each class was limited to approximately 8 to 15 employees at a time. Further, because manufacturing schedules had to be maintained, it was not feasible to halt routine operations in order to send entire organizations to Job Conditioning classes. As a result, Job Conditioning sessions were offered year-round, subject to availability. Other components of the Industrial Athlete program, such as Symptom Intervention, were offered to individual employees on an “as needed” basis.

A. Target Population

The initial target of the Industrial Athlete program were Boeing Commercial Airplane employees and manufacturing organizations considered to be at “high-risk” of an occupational injury or illness; generally speaking, these were employees working in the factory who actually assemble the airplanes and major components. Traditionally, these employees are the ones who had the highest injury rates and the most days away from work due to occupational injury. These employees are typically in the hourly pay category (Production and Maintenance), and have a variety of job titles including, but not limited to, “Assemblers Installers General,” “Assemblers Installers Structures,” “Aircraft Sealers” etc. Many, if not most, of these job categories are found in the Airplane Programs organization.

B. Program Components and Data Management

A database with proper access and security was developed to capture and store relevant data from the different elements of the Industrial Athlete program. For ease of data collection, the tool was web-based and deployed for use by the IA staff. The program components for which data are collected are described below.

Job Conditioning

The Job Conditioning (JC) program was designed to maximize an employee’s ability to handle the physical stresses of the job. The overall work demands of a crew and each individual in the crew are reviewed and then a customized conditioning program is created by the instructor. Program exercises focus on endurance, balance, flexibility and stability. The JC program was designed such that the employees would come to a location during their regular job shift and participate in physical conditioning led by an instructor. Typically, each crew comes to the conditioning class as a group. During the first visit, each employee fills out a questionnaire that asks about medical restrictions, and pre-conditioning physical measurements are obtained. These questions are meant to ensure that doctor’s clearance is obtained for employees with serious physical restrictions. The physical measurements include height, weight, range of motion, grip strength and sit-and-reach values. Attendance is taken at each JC class to keep track of who participated during that session. Since the program is voluntary, employees can choose to end their participation at any time. After the Job Conditioning session is completed, post-conditioning physical measurements are taken. In addition, a survey is sent out to the participants to collect post engagement information, such as whether or not they plan to continue some type of exercise routine.

Symptom Intervention

The Symptom Intervention (SI) program is designed to detect and treat the earliest symptoms of discomfort or pain before those symptoms progress to becoming an injury. The two components of Symptom Intervention are Deep Tissue Intervention and Athletic Training.

Deep Tissue Intervention

Deep Tissue Intervention (DTI) is a type of deep tissue therapeutic massage that is performed by trained DTI therapists who understand the work the employee performs on the factory floor. DTI is geared toward reducing discomfort in specific body areas, restoring musculoskeletal balance, and
helping employees get back to a more productive life. Each session is 20 minutes long and the employee comes to the DTI therapist in a factory location for the session. The DTI therapist records the employee ID, date and time of the DTI session, body part that was causing discomfort as well as discomfort measures between 0 (no discomfort) and 10 (unbearable pain) before and after the DTI session. If a discomfort measure was not recorded, then the missing values were coded with a 99.

Athletic Training
Athletic Training (AT) is meant to assess and resolve early symptoms and educate employees on self-care techniques to avoid future symptom progression or injury. Certified Athletic Trainers assess symptoms, apply first aid techniques such as ice, tape, and manual therapy, and provide body mechanics training and postural education to relieve discomfort based on employee symptoms. Visits can be categorized as either an initial visit or follow-up visit(s). The Athletic Trainer records data on employee ID, date, initial or follow-up visit, body part, pain or discomfort scale, and provides recommended actions for the employee.

Other Industrial Athlete Program Components
The Work Hardening component of the IA program, which only pertains to those employees already missing work due to occupational injury, is not tracked in the Industrial Athlete database. We do not analyze this component of the Industrial Athlete program in this paper.

III. PROGRAM UTILIZATION
Based on the data captured in the Industrial Athlete database through May 27, 2014, we can determine the number of employees who have participated in one or more of the IA program components. A total of 30,375 employees have gone through the IA program since its inception in 2005. Figure 1 below shows the number of employees participating in each of the programs.

![Venn diagram of the number of employees in the different Industrial Athlete programs.](image_url)

Based on Figure 1, we see that all three programs had very good participation. Almost 45% of the participants (13,733 out of 30,375) participated in more than one program element. This suggests that the employees may feel the benefit after participating in one program element and then come back to participate in another, although we did not have specific data to verify this assumption. Among the 30,375 employees, 24,752 are current employees in WA. The number of Production and Maintenance workers in WA, our target group, is 30,988 out of which 17,447 or 56.3% have participated in one or more of the IA programs.

Monthly participation in the IA program by the different sites in the Puget Sound area are given in Figure 2.
Figure 2: Monthly participation of employees in the Industrial Athlete program at different sites around Puget Sound.

Note that the participation in Everett jumped in 2011 which coincided with the push at the site to have all the new production employees hired into the 777 program go through the new job conditioning program as well as the addition of Athletic Trainers at shipside support for 777 and 787 manufacturing. Shipside support refers to having athletic trainers positioned in proximity to the actual assembly operations for convenient access by employees. From Figure 2 we also see that the participation at the other sites are fairly steady over time after an initial ramp up. Also remember that the number of employees vary by site and so the proportion of employees making use of the IA program is quite stable across the sites.

IV. ANALYSIS

A. Analysis Outcomes

The outcomes used in the analyses described in this paper refer to various types of “injury.” Specifically, the term injury refers to a health-related event experienced by an employee that meets the criteria specified by the Occupational Safety and Health Administration to be considered a work-related injury. There are different types of work-related injuries.

A “recordable” injury is a work-related injury for which “medical treatment” was provided to the employee, or for which other conditions applied, such as the employee lost consciousness, or missed at least one full day of work. In general, “medical treatment” involves providing care to the employee that is more than “first aid.” OSHA (2009) at their web site discusses first aid versus medical treatment.

An “ergonomic” injury is a work-related injury that is thought to have occurred because of repeated actions or motions an employee participates in during their work tasks. Ergonomic injuries are also known as “musculoskeletal” or “repeated trauma” injuries. In Boeing, the specific criteria for defining ergonomic injuries has been published elsewhere (Wechsler et al., 1998).

A “lost workday case” or “lost workday injury” is a work-related injury that resulted in the employee missing at least one full day (i.e., work shift) of work. Note that an injury is considered to be a lost workday case irrespective of the number of lost workdays involved; for example, a lost workday case does not distinguish between an injury resulting in one day away from work or one hundred days away from work.

Many of the analyses discussed in this paper use “injury rates” as an outcome. Injury rates are calculated by using the number of injuries occurring during a period of time (numerator) in a group or organization, and a measure of the population at risk for developing an injury (denominator) during that same time period, for the same group or organization. When calculating injury rates, we were consistent with standard techniques used by Boeing, based on the Bureau of Labor Statistics (BLS) guidance. The BLS (2013) normalizes injury rates to represent 100 employees working a full year.

Given our knowledge of the success of the program, and human subjects protection requirements, it was not ethically responsible to prohibit access to otherwise eligible program participants to create a traditional randomized, blinded study comparing likelihood of injury. This eliminates our ability to perform common traditional analysis methods of comparison to a control group.

The detail analysis we present here include i) a pain and discomfort reduction due to participation in the Athletic Training and the Deep Tissue Intervention; and ii) survival
models for the time to injury for different injury categories (recordable, ergonomic and lost workday). However, before we discuss the detail analyses, we want to share with the readers a summary of some previous analysis including those of injury rates in the Initial Analysis section.

B. Initial Analysis

We have been analyzing the Industrial Athlete data from the beginning of the program. Here we summarize some of the findings from our earlier analysis before we discuss some of the recent analysis of the data. This earlier analysis is detailed in a Boeing Company Technical Report written by Basu, Song and Wechsler (2009). In this report, the authors focused mainly on Job Conditioning as this is one of the key pillars of the Industrial Athlete program. Initially, Job Conditioning was not uniformly implemented at all the sites, due to production constraints at each site. The first sites to implement Job Conditioning were Everett and Renton, where JC was implemented in 2005 and 2006, respectively.

The initial analysis focused on calculating injury rates by level of participation in the Job Conditioning program for Everett and Renton. This technique involved grouping employees based on the number of Job Conditioning sessions in which they participated, and calculating injury rates for each group of employees. For this analysis we only analyzed “long-time” employees (employees hired before 2005 and were employed at the end of 2007). In addition, we focused on the production and maintenance employee job codes. We also restricted the set of job codes to those which had at least 10% participate in the JC program. These restrictions were used so that we were assured of having comparable jobs represented in both the participant and non-participant categories of this voluntary program.

Whereas the Everett Job Conditioning classes were 1 hour long, twice a week, focused on physical conditioning, the Renton program was primarily a 15 minute daily stretching program with some conditioning elements. For the Everett Job Conditioning program, a trend of decreasing injury rates with increasing attendance was observed. Conversely, no such trend was observed with the Renton Job Conditioning program. Given these results, the Renton Job Conditioning trend was observed with the Renton Job Conditioning increasing attendance was observed. Conversely, no such trend was observed with the Everett Job Conditioning program with some conditioning elements. For the Everett Job Conditioning program, a trend of decreasing injury rates with increasing attendance was observed.

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In the injury rate analysis, we could not rule out the possibility that the observed trend in the Everett data was due to healthier employees, or individuals already predisposed to healthier lifestyles being more motivated to complete the Job Conditioning classes.

Therefore, we conducted another analysis of the Everett data using Survival Analysis techniques (Lawless, 1982), where each employee acted as their own control. Each employee’s pre-Job Conditioning injury history was compared to their post-Job Conditioning injury history. The duration of time between injuries before participating in Job Conditioning was compared to their injury experience after participation in the Job Conditioning program. Using each employee as their own control helped to minimize bias in the analysis due to individual factors such as motivation, which could not be assessed with the available data. In general, the survival analysis techniques found that the duration of time between injuries increases as the number of Job Conditioning sessions attended increase. We will discuss the basics of fitting survival curves in a subsequent section where we give details on an analysis of the Athletic Training program.

C. Discomfort/Pain Scale Analysis

For the Deep Tissue Intervention (DTI) and the Athletic Training (AT) programs, we ask the employees their discomfort level at a scale of 0 (No discomfort) to 10 (Unbearable pain) before and after treatment. Pain scale and comparison of before and after treatment measurements have been used in many studies (e.g. Ellerekamann et al., 2003 and Topolovec-Vranic et al., 2010). The next section shows the analysis of these pain scale measurement comparisons for before and after treatment for the DTI and the AT programs.

Deep Tissue Intervention Analysis

For each visit discomfort measurements was recorded, both before and after the Deep Tissue Intervention. However, sometimes a discomfort or pain measurement was not recorded and were then coded as missing (99). Out of the 144,639 visits, 3,070 visits had at least one missing discomfort level number. These were dropped from the analysis. A difference in the discomfort level (Before MINUS After) is seen as an initial measure of effectiveness of the DTI intervention, with a positive difference indicating pain relief.

The average difference from the pain scale measurements was 3.16 with the median at 3.0 and the standard deviation at 1.53. Assuming normality of the discomfort difference for before and after, the probability that a person will have an increase in discomfort after the DTI treatment is 0.0197. Figure 3 shows the frequency of the observed differences in discomfort level for the DTI treatments.

![Figure 3: Difference in Discomfort/Pain level before and after DTI. A positive number indicates reduction in pain.](image)

From Figure 3 we see that for 97.6% of the visits, the employee reported a reduction in discomfort after DTI, 2.4% reported having the same level of discomfort and 0.4% of the employees reported increase in discomfort. However, we need to be careful interpreting this reduction in discomfort.
level because of the human tendency to believe that there is a benefit (reduction in pain) if any intervention was performed. However, we assumed a discomfort level reduction of magnitude 2 or more points was unlikely to be explained by this tendency alone, and reflects meaningful discomfort reduction. 87.8% of the visits led to a reduction in discomfort of 2 or more points. Therefore, it is believed that most of the visits to the DTI therapist are beneficial to the employee, even if the benefit is temporary. Note that these numbers are consistent with our finding in 2009, and therefore the discomfort reduction benefits of DTI have held true over some period of time.

Athletic Training

Employees may choose to visit Athletic Trainers when they experience pain or discomfort while at work. During an Athletic Training engagement, the trainer evaluates and screens the employee’s symptoms. Depending on the evaluation, the Athletic Trainer could refer the employee to a physician, refer to DTI, evaluate the workspace, or provide guidance to reduce aches and pain. The first case of Athletic Training was recorded for January 8, 2006 in Renton, WA. A total of 31,018 AT cases are recorded from 14,009 employees who participated in the AT program until May 27, 2014. As part of each session, the Athletic Trainer gives several recommendations to the employee to reduce discomfort. The top recommendations are Stretching, Icing the area of discomfort, Body Mechanics, Posture Education, Taking Micro Breaks and Strengthening of the affected area. They sometimes refer the employee for medical attention or to other IA, Safety- or Well Being-related programs.

Not all AT cases had multiple visits. Out of the 31,018 cases, only 15,546 cases had multiple visits. Out of these 3,651 cases had a missing discomfort scale number for either the first or the last visit and these cases are not used for calculating the change in discomfort level. For cases with multiple visits \( n =11775 \), the discomfort level difference between the first and the last visit are calculated. A positive difference indicates that the discomfort level was lower for the last visit compared to the first visit. The average difference of the discomfort level was 2.33 with the median was 2.0 and the standard deviation was 2.88. Assuming normality of the discomfort level difference for before and after, the probability that a person will have an increase in discomfort after the AT treatment is 0.2090. Note that these numbers are higher than the DTI numbers. This could be due to the fact that when an employee engages with an Athletic Trainer, the discomfort is typically more severe and needs a more serious treatment (e.g. seeing a physician) than what an Athletic Trainer can provide.

Figure 4 shows these differences in discomfort level for AT with multiple visits.

Figure 4: Reduction in discomfort level for AT cases with multiple visits. The reduction is calculated by comparing the discomfort level between the first and the last visits. A positive number indicates a reduction in discomfort level.

From Figure 4 we see that 8.0% of the cases had increased discomfort, 13.4% had the same value, and 78.6% had a reduction in discomfort in the final visit compared to the initial visit. Since discomfort/pain scale measurements are subjective, if we took a reduction in discomfort level of 2 or more to be substantial, 62.8% of the cases had a substantial reduction in the discomfort level. In addition, it can also be assumed that many of the AT cases with no follow-up visit was due to a reduction in discomfort after the AT visit.

D. Time to Injury Analysis

When analyzing time to injury after an AT intervention, it is important to understand how we treat the time because we can have an intervention before an injury occurs or there could be no injury when we are analyzing the data. These types of data are called censored lifetime data and need special handling. Lawless (1982) is an excellent reference for details on dealing with lifetime data and in this paper, we will just mention a few concepts and an estimator that we use for analysis.

Survivor and Hazard Functions

We now briefly discuss the concepts of the survivor and the hazard functions. Most of the text below is taken, with modification, from the book by Lawless (1982). We begin by considering the case of a single lifetime variable \( T \). In our case here it is the time to injury after AT. Note that the random variable \( T \) is non negative and can be treated as continuous. Let \( f(t) \) denote the probability density function of \( T \). Let the cumulative distribution function (CDF) of \( T \) be denoted as

\[
F(t) = P(T \leq t) = \int_{0}^{t} f(x)dx.
\]

Note the \( F(t) \) is the probability that the time to injury is less than \( t \). The probability of an employee not having an injury till time \( t \) is called the survivor function and is denoted as

\[
S(t) = 1 - F(t) = P(T > t) = \int_{t}^{\infty} f(x)dx.
\]
\[ S(t) = 1 - F(t) = \Pr(T \geq t) = \int_{t}^{\infty} f(x) \, dx. \]

Note that \( S(t) \) is a monotone decreasing continuous function with \( S(0) = 1 \) and \( S(\infty) = \lim_{x \to \infty} S(t) = 0 \).

Another important concept having to do with life distributions is the hazard function \( h(t) \). A hazard function specifies the instantaneous rate of injury at time \( t \), given that the employee is not injured till time \( t \). It is denoted as
\[ h(t) = \lim_{\Delta t \to 0} \frac{\Pr(t \leq T \leq t + \Delta t | T \geq t)}{\Delta t} = \frac{f(t)}{S(t)}. \]

The functions \( f(t) \), \( F(t) \), \( S(t) \), and \( h(t) \) give mathematically equivalent specifications of the distribution of the inter-injury time \( T \). It can be shown that the survivor function, \( S(t) \), and the hazard function, \( h(t) \), are related by
\[ S(t) = \exp\left( -\int_{0}^{t} h(x) \, dx \right). \]

There are several parametric distributions that can be used as the CDF for lifetime data. The Weibull (Weibull, 1951) distribution is the most widely used lifetime distribution model.

The pdf \( f(t) \) of the Weibull distribution is given by
\[ f(t) = \lambda \beta [\lambda t]^{\beta-1} \exp[-(\lambda t)^\beta] \quad t > 0 \]
where \( \lambda > 0 \) and \( \beta > 0 \). The survivor function and the hazard functions are
\[ S(t) = \exp[-(\lambda t)^\beta] \quad t > 0 \]
and
\[ h(t) = \lambda \beta \exp[-(\lambda t)^{\beta-1}] \quad t > 0. \]

When \( \beta = 1 \), the Weibull distribution reduces to the exponential distribution.

Another way to portray survival data is to compute and graph the empirical survivor function. This also provides a nonparametric estimate of the survivor function for the inter-injury times. If there are no censored observations in a sample of size \( n \), then the empirical survivor function is defined as
\[ \hat{S}(t) = \frac{\text{Number of observations} \geq t}{n} \quad t \geq 0. \]

This is a step function that decreases by \( 1/n \) just after each observed lifetime if all the lifetimes are distinct.

When dealing with censored data, as is the case here, modifications are needed and were first proposed by Kaplan and Meier (1958). The modifications are called the product-limit or the Kaplan-Meier estimate of the survivor function. The estimate is defined as follows: Suppose that there are observations on \( n \) individuals and that there are \( k \) \( (k \leq n) \) distinct times \( t_1 < t_2 < \ldots < t_k \) at which injuries occur. Let \( d_i \) represent the number of injuries at \( t_i \). In addition to the lifetimes \( t_1, t_2, \ldots, t_k \), there are also censoring times \( L_i \) for individuals whose lifetimes are not observed. The product limit estimate of \( S(t) \) is defined as
\[ \hat{S}(t) = \prod_{t_i < t} \frac{n_i - d_i}{n_i} \]
where \( n_i \) is the number of individuals at risk at \( t_i \), that is, the number of individuals not injured and uncensored just prior to

\( t_i \). The CDF is estimated as \( \hat{F}(t) = 1 - \hat{S}(t) \) and is shown in the results with the 95% confidence bounds.

Basu, Song and Wechsler (2009) analyzed the lifetime data for Job Conditioning and showed the effectiveness of the JC program. In this paper, we will calculate the probability of injury after an AT engagement using Kaplan Meier estimates.

**Results for Injury after AT Analysis**

The Athletic Trainer works on a particular body part that is causing discomfort for the employee. Although there are numerous body parts, we combined them into eight groups. These are Foot/Ankle, Lower Extremity, Lumbo-Pelvic, Cervical/Thoracic, Upper Extremity, Hand/Wrist, Head and Other. Figure 5 shows a schematic of the body part groupings.

![Figure 5: Body part groupings used for the AT analysis.](image)

Note that we could not distinguish between the left and the right side of the body because these were not distinguished in the database. The body part information from the injury data were also grouped in the same way. This let us analyze the injury information from the same body part that was treated during AT. This was done to make sure that if an injury happened after an employee engaged with an Athletic Trainer, the injury was related to the same body part the AT was working on and not to an unrelated body part.

The three typical scenarios of injury of the same body part after AT are given in Figure 6.
Figure 6: Scenarios for AT and injury occurrence after AT for the same body part.

The vertical line on the right in Figure 6 denotes the end time for the study. In the results to follow this date is April 30, 2014. The brackets with the words “AT” shown in Figure 6 represent the beginning and end dates of an AT case. In the top scenario, there is no injury since AT. In this case we do not know if or when an injury will occur. We do know that the injury time is at least the number of days since the end of AT to the analysis date. In the middle scenario, there is an injury after AT and we know the exact days to injury after AT. In the third case, the injury happened during the dates when the AT case was open. We assign days to injury to be zero for this scenario. In the above three scenarios, the days to injury is censored for the top case and known for the other two cases.

To analyze the Injury after AT, we also had to define criteria for determining whether a visit to a trainer was a “new AT case,” versus a continuation of a preexisting condition. We decided to use a 30 day window to combine AT cases. In other words, if the closed date of an AT case and the open date of another AT case for the same body part and for the same employee occurred within 30 days, we consider them to be a single AT case.

The AT program had a new vendor since September 2009. Given that there could be an initial effect of having a new vendor implement the AT program, the injury after AT analysis only used AT engagements that had the last date of engagement after Jan 1, 2010. The Probability of injury curves were calculated using the Kaplan-Meier estimates and are shown in Figures 7-9 along with the 95% confidence bounds.

Figure 7: Probability of Injury after AT for Recordable Injuries.

Figure 8: Probability of Injury after AT for Ergonomic Injuries.

Figure 9: Probability of Injury after AT for Lost Workday Injuries.

Figures 7-9 show that the KM estimate of the probability of injury at time zero is positive indicating that there are some injuries that happen while the employee was engaged with the Athletic Trainer. The close date being after the injury date indicates that the Athletic Trainer closed the case during the next AT visit as per policy.

Table 1 gives the probability of injury for several time periods after the last AT visit. We wanted to look at probability of injury after 30 days, 90 days, 180 days and 1 year. These were calculated based on the Kaplan Meier estimates of injury data after AT. Recall that we only used AT information that were completed after Jan 1, 2010 and the injury for the same body part. We also compared these results with only those AT cases that had more than one visit.

Table 1: Probability of injury after AT using Kaplan Meier estimates.
Note that the probability of injury after AT for the same body part is highest for recordable injuries and lowest for Lost Workday injuries with ergonomic injuries falling in between. At the end of a year, the probability of injury for recordable injuries is 3.6%, for ergonomic injuries is about 2.6% and for Lost Workday injuries is about 0.6%. Note that the probability of injury is slightly higher for those who come for multiple visits. This is probably because an employee will tend to come multiple times if the discomfort issue is not resolved after a single visit with the Athletic Trainer. This may indicate a more serious issue, which may lead to a higher chance of injury later.

AT is implemented at the different sites in Puget Sound. We wanted to compare the estimates of probability of injury after AT for the different sites (Auburn, Everett, Frederickson and Renton). The Kaplan Meier estimates for the probability of injury are given in Figures 10-12 for all AT cases by site.

Table 2 shows that probability of injury estimates for the different sites and for the different injury types.

<table>
<thead>
<tr>
<th>All AT cases</th>
<th>AT Cases with Multiple Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recordable</td>
</tr>
<tr>
<td>30 Days</td>
<td>0.0162</td>
</tr>
<tr>
<td>90 Days</td>
<td>0.0208</td>
</tr>
<tr>
<td>180 Days</td>
<td>0.0262</td>
</tr>
<tr>
<td>1 year</td>
<td>0.0355</td>
</tr>
</tbody>
</table>

Figures 10-12 show that there is little difference by site. We tested the equality of the survival curves from the different sites using both the Log-Rank and the Wilcoxon tests (Kalbfleisch and Prentice, 1980). For the recordable injuries the p-values are 0.204 and 0.393, respectively for Rank and Wilcoxon Tests. For the ergonomic injuries, the p-values are 0.178 and 0.322. However, the p-values were small (< .001) for the Lost Workday injuries comparison of the sites and the differences were mainly due to the differences in the Everett and the Renton sites with Renton having the lowest probability of having a Lost Workday injury from the same body part.

Table 2 shows that probability of injury estimates for the different sites and for the different injury types.
From Table 2 we see that there is very little difference in probability of injury for both recordable and ergonomic injuries of the same body part, but for the Lost Workday injuries, Renton has much lower estimates.

V. CONCLUSIONS

In this paper we described the Boeing Industrial Athlete program along with the data that are collected in this program. Currently, the Boeing IA program is only in the Puget Sound area, but based on the effectiveness of the program other Boeing sites in the US are investigating ways to start IA at their sites. The IA program management decided to capture elements of the program for the purposes of analyzing outcomes data. We discussed how, based on a previous analysis of the Job Conditioning program, all sites in Puget Sound now use a standard JC program comprising of 60 minutes, 2 days a week for 7 weeks. We also analyzed the reduction in discomfort after an employee receives a Deep Tissue Intervention or engages with an Athletic Trainer. Both the AT and the DTI programs were effective in reducing discomfort.

We discussed how, in a previous analysis we used statistical survival analysis techniques and compared time to injury before and after participation in JC classes. Those results showed the JC program is effective at increasing the elapsed time before an injury occurs. We also showed how Athletic Training participants show very small probability of injury of the same body part after AT even when we look at this probability after one year. We also compared these probabilities across sites. There were no differences across sites for Recordable and Ergonomic injuries, but for Lost Workday injuries, the Renton site had statistically lower probability than the other sites.

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REFERENCES


BIographies

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