ISSN: 2231-2196 (Print) ISSN: 0975-5241 (Online)

International Journal of Current Research and Review (IJCRR)

Volume No. 17
Issue No. 2
May - August 2025

ENRICHED PUBLICATIONS PVT. LTD

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ISSN: 2231-2196 (Print) ISSN: 0975-5241 (Online)

International Journal of Current Research and Review (IJCRR)

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Contents

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GREEN IT BASED ENERGY EFFICIENCY MODEL FOR DATA CENTERS TO REDUCE ENERGY CONSUMPTION

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ABSTRACT

Problem Statement: The advancement of Information and Communication Technologies (ICTs) based business and social practices in the last few decades has transformed many, if not most, economies into e-economy and businesses into e-businesses. For economies, ICTs are increasingly playing critical roles in transforming and generating ortunities. On the other hand, global warming and climate change coalescing with limited availability and rising cost of energy are posing serious challenges for the sustainability of the global digital (or otherwise) economy. Technology has a potential to create sustainable business and society both in grim and green economic times. Especially, the recovery from the current economic crisis is going to need and lead to more Greener and energy efficient industries. As corporations look to become more energy efficient, they are examining their operations more closely. Data centers provide capabilities of central storage, backups and networking, recovery. Data centers are found major culprits in consuming too much energy in their overall operations and generating too much CO2. In order to handle the sheer magnitude of today‘s data, data centers have had to use much more power and servers have become larger, denser, hotter and significantly more costly to operate. This study determine the properties and attributes of green IT infrastructures and determines the way it will be helpful in achieving green sustainable businesses. The proposed Green IT model will be drafted using Virtualization technology for data centers to make them more energy efficient and green, hence reducing the emission of green house gases so that the overall effect on global warming can be reduced or even eliminated. Results & Conclusion: The proposed model would reveal the qualities of green IT to enhance the proper utilization of hardware and software resources available in the data center. It helps data center managers to come up with a new environment friendly and sustainable green IT strategy making environment greener and sustainable. The heart of this strategy is to reduce global warming effects by using green and energy efficient data centers.

Key words: Virtualization complements, server consolidation, considerations, data environmental centers, energy efficiency, reduce energy, environmental issues, energy efficient, environmental impact, resource allocation,

INTRODUCTION

Seldom does a day pass in which we don‘t hear or read about sustainability or “going green.” Environmental concerns are constantly in news headlines and the impact of technology on our environment is significant. Large technology organizations such as Dell, HP, ISM, Sun, Hitachi and Fujitsu have introduced green and sustainable initiatives. “Green” is generally understood to mean “Friendly to the environment and energy efficient.” Sustainable implies planning and investing in a technology infrastructure that serves the needs of today as well as the needs of tomorrow while conserving resources and saving money. Organizations are quite concerned with environmental issues,

but they have also come to realize that sustainable business practices can significantly enhance the bottom line. Data centers are changing at a rapid pace; more than any other industry in history. Yet with all the change, data center facilities and IT professionals face numerous challenges in unifying their peers to solve problems for their companies. Sometimes you may feel like you are talking different languages or living on different planets. The data centers have become an increasingly important part of most business operations in the twenty-first century. With escalating demands and rising energy prices, it is essential for the owners and operators of these mission critical facilities to assess and improve their performance. In contexts ranging from large-scale data centers to mobile devices, energy use is an important concern. In data centers, power consumption in U.S has doubled between 2000 and 2006 and will double again in the next five yearsn (EPA, 2006). Server power consumption not only directly affects a data center‘s energy costs, but also necessitates the purchase and operation of cooling equipment, which can consume one-half to one Watt for every Watt of power consumed by the computing equipment (Suzanne, 2008). As new servers are being added continuously into data centers without considering the proper utilization of already installed servers, it will cause an unwanted and unavoidable increase in the energy consumption, as well as increase in physical infrastructure like over-sizing of heating and cooling equipments. This increased consumption of energy causes an increase in the production of green house gases which are hazardous for environmental health. Hence it not only consumes space, energy, but also cost environmental stewardship (Mueen and Azizah, 2010). The continued growth of data center power consumption impacts everything from the business enterprise to the power supply companies to the environment. With more efficient energy use in data centers, power supply companies will face less demand and the possibility of excess power, which could help limit blackouts, reduce carbon dioxide output and cut other green house gases.

In addition, energy use has implications for reliability, density and scalability. As data centers house more servers and consume more energy, removing heat from the data center becomes increasingly difficult (Chandrakant and Patel, 2003). Since the reliability of servers and disks decreases at high temperatures, the power consumption of servers and other components limits the achievable density of data centers, which in turn limits their scalability. Furthermore, energy use in data centers is starting to prompt environmental concerns of pollution and excessive load placed on local utilities (Chandrakant and Ranganathan, 2006). These concerns are sufficiently severe that large companies are starting to build data centers near electric plants in cold-weather environments (John and Hansell, 2006). For the business enterprise, an increase in data center efficiency can save significant energy costs. However, even with the global presence of many companies, these metrics are often not applied consistently at a global level. All of these factors are increasing the public‘s awareness and global concerns of these current power consumption trends.

We‘re in the biggest data centre construction boom in history. The U.S. is spending $16 billion a year building out additional data centers, with another $6 billion on refurbishing existing ones. Experts say we should be spending $3 billion a year to build new electrical power plants to meet the supply needs of these data centres-except we‘re not (EPA, 2009).The Smart 2020 report published by the Climate Group and GeSI revealed that in 2002, the global data centre footprint, including equipment use and embodied carbon, was 76 MtCO2e and this is expected to more than triple by 2020-259MtCO2e, making it the fastest-growing contributor to the ICT sector‘s carbon footprint, at 7 per cent per annum in relative terms. If growth continues in line with demand, the world will be using 122 million servers in 2020, up from 18 million today (Smart, 2020).

With energy prices increasing worldwide the operational costs of data center continues to increase steadily. Besides the cost, availability of electrical power is becoming a critical issue for many companies whose data centers have expanded steadily. Enterprises, governments and societies at large have a new important agenda: tackling environmental issues and adopting environmentally sound practices. Over the years, the use of IT has exploded in several areas, improving our lives and work and offering convenience along with several other benefits. We are passionate about advances in and widespread adoption of IT. However, IT has been contributing to environmental problems, which most people don‘t realize. Computers and other IT infrastructure consume significant amounts of electricity, placing a heavy burden on our electric grids and contributing to greenhouse gas emissions. Additionally, IT hardware poses severe environmental problems both during its production and its disposal. IT is a significant and growing part of the environmental problems we face today. We are obliged to minimize or eliminate where possible the environmental impact of IT to help create environment. a To more sustainable reduce It‘s environmental problems and to create a sustainable environment, we call upon the IT sector as well as every computer user to green their IT systems, as well as the way they use these systems (Murugesan, 2008). We are legally, ethically and socially required to green our IT products, applications, services and practices. Green IT benefits the environment by improving energy efficiency, lowering greenhouse gas emissions, using less harmful materials and encouraging reuse and recycling. Factors such as environmental legislation, the rising cost of waste disposal, corporate images and public perception give further impetus to the green IT initiative. Green IT is a hot topic today and will continue to be an important issue for several years to come. To foster 3 green IT, we should understand: What are the key environmental impacts arising from IT? What are the major environmental IT issues that we must address? How can we make our IT infrastructure, products, services, operations, applications and practices environmentally sound? What are the regulations or standards with which we need to comply? How can IT assist businesses and society at large in their efforts to improve our environmental sustainability? This study will highlight some of these issues and then presents a holistic approach to greening IT in e businesses especially data center industry. We propose a green IT strategy for data centers and outline specific ways to minimize IT‘s environmental impact.

Challenges of Data Center Industry

Power outage has been mentioned as one of the most experienced and perceived risks by various types of businesses and organizations. Thus, reducing the impacts of power outage has become a key agenda in business continuity planning. Back-up or stand-by generators are among the most well known measures taken by power consumers to tackle the power outage problem (Asgary A., and Jahromi). There‘s no single bad guy that can be blamed for ITinefficiency. Worse, inefficiency seems to grow incrementally over time as environment becomes older and more complex. Each new application being added seems to require another server,which requires administrative time to keep running, while it consumes power, space and expensive network ports in your data center. The data center industry has a number of related problems such as:

1. Inconsistent Measuring Metrics & Benchmarks

It is significantly important for data center managers to measure the performance of their data centers regularly so that efficiency measures should be performed to make data centers energy efficient and green. But unfortunately there is no industry standard metric available acceptable worldwide to measure the performance in terms of energy efficiency and CO2 emissions. Data center managers are currently

equally split between using external benchmarks, home grown tools, financial analysis and commercial asset/financial management tools, with no clear leader and metric. It is evident from different discussions that measuring IT performance is difficult.

2. Outsized Number of Underutilized Servers

Servers are the major components responsible for performing most of the processing being performed in data centers. There number is continuously increasing as the demands from businesses grow. Due to their increased number they are the leading consumer of IT power in any data center. Data centers are plagued with thousands of the server‘s mostly underutilized, having utilization ratio of only 5-10% consuming huge energy and generating huge amount of green house gases (Mueen and Abdul Rahman, 2010).

3. Power Efficiency of IT Equipment

Data center comprises many types of equipment like servers, UPS, PDU‘s, chillers, Cracks. All of these components consume enormous amount of power to provide services to end users. Most of the data managers think that IT equipments are significant source of electrical waste. Proper efficiency measures can reduce these consumptions and help data center managers implement environment friendly and green data centers.

Establishing Performance Requirements and Maximizing IT Operations

Effective application service delivery requires a continuous understanding of end-to-end application performance requirements. In a data center environment, with rapidly changing dynamic workload and resource allocation, continuous measurement to establish performance requirements is especially vital. This understanding should start when the applications are still in development, so that IT can avoid any surprise performance problems during and immediately after production deployment. As application usage changes, continuous measurement is required to adapt workload and resource allocation and maintain service levels. When application changes are made, or new features are added, performance requirements will need to be re-established to again avoid potential disruption.

Environmental Issues & Problems

The growing accumulation of greenhouse gases is changing the world‘s climate and weather patterns, creating droughts in some countries and floods in others. It‘s slowly pushing global temperatures higher, posing serious problems to the world (http://egj.lib.uidaho.edu/index.php/egj/arti cle/view/3205/3175). For instance, 2005 was the warmest year on record and the 10 warmest years have all occurred since 1980. Global data shows that storms, droughts and other weather-related disasters are growing more severe and more frequent. To stop the accumulation of greenhouse gases in the atmosphere, global emissions would have to stop growing. Electricity is a major cause of climate change, because the coal or oil that helps generate electricity also releases carbon dioxide, pollutants and sulphur into the atmosphere. These emissions can cause respiratory disease, smog, acid 4 rain and global climate change. Reducing electric power consumption is a key to reducing carbon dioxide emissions and their impact on our environment and global warming. With this in mind, let‘s focus on what each of us as IT professionals, members of the IT industry and IT users can do individually and collectively to create a sustainable environment. Let‘s examine IT‘s environmental impact and consider green IT measures that we can adopt.

PROPOSED WORK

Greening Data Centers

The continued rise of Internet and Web applications is driving the rapid growth of data centers. Enterprises are installing more servers or expanding their capacity. The number of server computers in data centers has increased six fold to 30 million in the last decade and each server draws far more electricity than earlier models. Aggregate electricity use for servers doubled between 2000 and 2005, most of which came from businesses installing large numbers of new servers (Pritchard, 2007). One problem with the greening of IT is that it forces organizations to buy more. Plans usually call for things like more energy efficient servers, intelligent sensors for data center cooling, server virtualization software, low power monitors and devices that turn off dormant computers (Baines, 2007). The social, financial and practical constraints involved will force businesses and IT departments to reduce energy consumption by data centers. We can improve data center efficiency by using new energyefficient equipment, improving airflow management to requirements, reduce investing in cooling energy management software and adopting environmentally friendly designs for data centers and new measures to curb data centers energy consumption. Three key areas identified for improvement in achieving energy efficient data center are:

- Revising processes and metrics
- Optimizing efficiency of existing IT assets
- Revamping architecture and infrastructure

Revising Processes & Metrics

Changing organizational processes and measurements is a subtle but vital part of any transformation effort. Changes in processes and metrics will drive changes in behavior, which in turn will underpin all the other technology or architecture changes that a data center makes. By focusing on processes and metrics, data center managers must ensure that green does not become a “bolt-on” to the business, but rather is integrated into employees work. Process changes will extend beyond the IT organization; in fact, one of the principal goals of these activities is to foster closer collaboration among IT leadership, sourcing and vendor management and facilities or real estate functions. A policy should be drafted to revise procurement criteria to favor green suppliers, products and sustainable business practices. Benchmarking should be done for energy consumption and Co2 emissions of prospective equipment purchases using standards like Energy Star, EPEAT, Green Grid and others. Favor products with longer potential life cycles and with smaller total carbon footprint. It is also very important to emphasize on recycling programs for both consumable and durable IT assets. Performance goals should be set for teams and individuals to conform to green practices and principles. It is also necessary to implement an energy monitoring and management system to benchmark the performance of data center from time to time so that new techniques and measures should be implemented to make them green and environment friendly. Green criteria should be built into existing performance management systems, balanced scorecards and measurement metrics, data center managers are already using to measure, incant and reward performance. Revise the employee competency or maturity model to include sustainability competencies and skills.

Optimizing Efficiency of Existing IT Assets

A data center consists of many types of equipment and devices needed to accomplish the business needs and to provide services to the end users. These services vary depending on the different optimization priorities depending on its green IT goals, appetite for change and current infrastructures. It is pertinent

here to note that data center managers must reconfigure data center equipments so that green initiatives can implemented and energy efficiency goals should be achieved. Some of the proposed initiatives are:

- Move to hot aisle/cold aisle arrangement
- Reposition and unblock air vents Simplify cabling systems
- Moving to overhead configuration if possible
- Group equipment with similar power and cooling requirements together in modular fashion
- Instrument equipment with temperature and power consumption sensors
- Upgrade power supplies, converters, UPS systems and CRAC systems
- Optimize data center thermals via precision cooling and other techniques
- Implement server and/or storage virtualization, tiring and consolidation
- Implement networked PC power management system
- Lengthen PC life cycle

Revamping Architecture & Infrastructure

Revising processes and optimizing assets will yield significant green and cost benefits for most of the data centers. Green initiatives will create an opportunity to go further and delve into revamping IT infrastructure and architectures. Data center managers must implement thin client systems to replace desktop PC populations. Upgrade older server and storage gear with more energyefficient models. Consolidate, relocate, or outsource data centers. Reduce energy usage with building automation systems and evaluate alternative energy technologies and suppliers. New improved infrastructures using green metrics should be adopted and implemented to save the overall cost of ownership of data centers.

Proposed Green IT Model for Data Centers

This study highlights the importance of green IT for data centers and proposes a model that provides data center managers with guidelines and steps to be followed to make data centers energy efficient and green. The proposed model comprises of five optimization steps. The proposed green IT model specifies that energy consumption, underutilization, emission of green house gases, environmental concerns, global warming issues and intensive administrative labour that contribute This study highlights the importance of green IT for data centers and proposes a model that provides data center managers with guidelines and steps to be followed to make data centers energy efficient and green. The proposed model comprises of five optimization steps. The proposed green IT model specifies that energy consumption, underutilization, emission of green house gases, environmental concerns, global warming issues and intensive administrative labour that contribute towards data center inefficiency can be tackled by following the proposed green IT model. The proposed model is an effort to help data center industry specially tier level data center managres to apply green IT initiatices in their data centers to achieve efficiencies in terms of energy utilization, energy consumption and reduction of emission of green house gases very hazardous for enevironmental health and global warming.

The proposed Green IT model compriess of five key steps to be followed by data center managers to apply the model in their respective environments so that efficiency can be achieved.

The model consists of follwing five key elements:

- Baseline your current environment
- Implement Virtualization (Server Virtualization)
- Consolidate IT Processes
- Improve data center efficiency
- Update IT processes

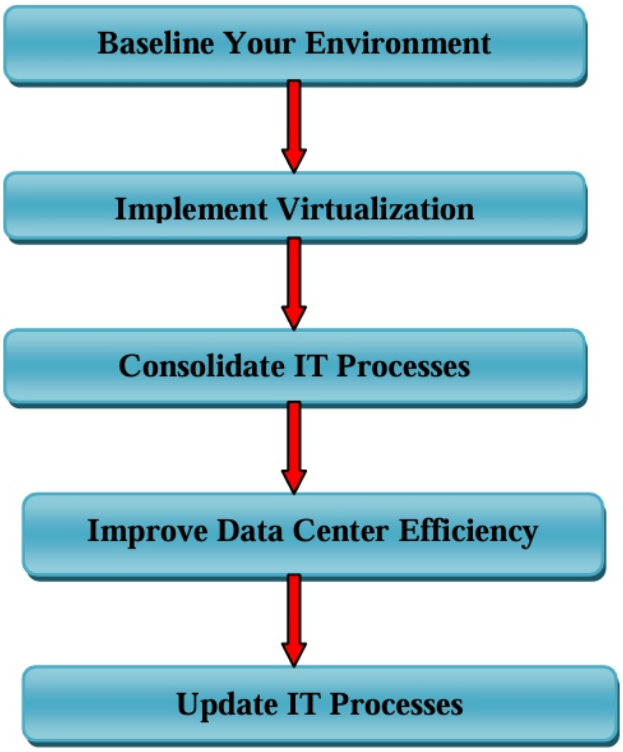

Fig. 1: Proposed Green IT Model for Data Centers

The proposed model highlights top IT improvements in data center spanned across data center energy efficiency, infrastructure consolidation, reduced administrative labor, better IT process, improved service time and reduces green house gases to reduce the effects of global warming hazardous for environmental health. These benefits may vary significantly across businesses of different types. In particular, companies with less than $1 billion in revenue said that they benefited more from physical consolidation of IT assets, whereas companies with $5 billion or more in revenue benefited the most from improving the energy efficiency of their data centers.

1. Baseline your Environment

The first step in greening the data center is to baseline all the requirements to get the maximum value out of data center greening program. Now more than ever, energy efficiency seems to be on everyone‘s minds. Faced with concerns such as global warming and skyrocketing energy costs, more and more companies are considering if and how to increase efficiency. E businesses that rely on data centers must make hard decisions to accommodate growing demands without creating a negative impact on their finances or the environment. The data center baseline Study report must be based on in-depth interviews with engineers and data center managers. These professionals represent a cross-section of companies in terms of industry, size, number of servers, storage capacity, age, geography.

The baseline study provides measures to boost efficiency, as well as the incentives for making changes data center energy efficient. The growth in IT demand is among the most common obstacles to becoming more energy efficient. Data centers must contend with constant expansion in data volume, along with new and extended application requirements. The study also gets awareness about how to calculate the power load of individual IT devices. The data center baseline report also outlines helpful strategies for approaching energy efficiency in the data center. The discussion covers virtualization, air-flow management, server decommissioning, equipment upgrades, storage consolidation and optimization and use of fresh-air cooling and renewable energy sources. The report also includes tips on how to improve energy efficiency in the data center so that other data center professionals can evaluate their options and identify the most appropriate steps for their particular organizations.

1.1 IT Discovery Process

The process of creating the baseline of your data center starts by creating an inventory of all resources including servers, resources they require, available resources and their associated workloads, this process is called discovery process. The inventory process includes both utilized and idle servers. It also includes information related to (Mueen and Abdul Rahman, 2010):

- Make and Model of the Processor
- Types of processors (socket, Core,
- Threads, Cache)
- Memory size and speed
- Network type (Number of ports, speed of each port)
- Local storage (number of disk drives, capacity, RAID)
- Operating system and their patch levels (service levels)
- Applications installed
- Running services

1.2 Inventory

It is very important for an organization to know in advance the total content of its infrastructure before implementing green IT techniques. This is the most important step in Greening IT project. There are many tools available from different vendors for performing initial analysis of an organization. Microsoft Baseline Security Analyzer (MBSA) tool provides different information like IP addressing, Operating System, installed applications and most importantly vulnerabilities of every scanned system. After analyzing, all generated values are linked to MS Visio, which generates a complete inventory diagram of all components and also provides details about each component being analyzed. Microsoft Assessment and Planning toolkit (MAP) is another tool for the assessment of network resources. It works with windows management instrumentation (WMI), the remote registry service or with simple network management protocol to identify systems on network. VMware, the founder of X-86 virtualization, also offers different tools for the assessment of servers that could be transformed into virtual machines.

VMware Guided Consolidation (VGC) a powerful tool assesses network with fewer than 100 physical servers. Since VGC is an agent less tool it doesn‘t add any overhead over production server‘s workload.

1.3 Categorize Server Resources

After creating server inventory information, the next step is to categorize the servers and their associated resources and workloads into resource pools.This process is performed to avoid any technical political, security, privacy and regulatory concern between servers, which prevent them from sharing resources. Once analysis is performed, we can categorize each server roles into groups. Server roles are categorized into following service types:

- Network infrastructure servers
- Identity Management servers
- Terminal servers
- File and print servers
- Application servers
- Dedicated web servers
- Collaboration servers
- Web servers
- Database servers

1.4 Categorizing Application Resources

After categorizing servers into different resource pools, applications will also be categorized as:

- Commercial versus in-house
- Custom applications
- Legacy versus updated applications
- Infrastructure applications
- Support to business applications
- Line of business applications
- Mission critical applications

1.5 Utilization data

Aggregate utilization data helps initially to target particular servers and storage devices as candidates for consolidation. But it doesn‘t tell the whole story, since many servers are busy for short periods of time on a periodic basis. In that case system management tools should be used to collect trends for the entire cycle of systems with applications s that run on a weekly, monthly, or quarterly basis. Some capacity or consolidation planning tools can simplify this task by superimposing historic data for multiple systems to simplify analysis.

1.6 Performance Modeling & Consolidation Plan

To optimize the consolidation scenarios, consider using performance modeling and consolidation planning tools to analyze different consolidation and virtualization scenarios. Different consolidation strategies can be y between dissimilar systems or those that will compete for resources at the same time.

2. Implement Virtualization

Virtualization promises to dramatically change how data centers operate by breaking the bond between physical serversand the resource shares granted to customers. Virtualization can be used to “slice” a single physical host into one or more Virtual Machines (VMs) that share its resources. This can be useful in a hosting environment where customers or applications do not need the full power of a single server.

In such a case, virtualization provides an easy way to isolate and partition server resources. The abstraction layer between the VM and its physical host also allows for greater control over resource management. The CPU and memory allocated to a virtual machine can be dynamically adjusted and live migration techniques allow VMs to be transparently moved between physical hosts without impacting any running applications.

2.1 Server Virtualization

In order to minimize the overall network traffic in a multiserver system, the number of users served by each server (and hence the group size) should remain constant. As the underlying traffic fluctuates, a split and merge scheme is implemented in a physical server to achieve load balancing (R. Sukumar and V. Vasudevan, 2009). Server virtualization has become popular in data centers since it provides an easy mechanism to cleanly partition physical resources, allowing multiple applications to run in isolation on a single server. It categorizes volume servers into different resource pools depending on the workloads they perform and then server consolidation is applied. This technique decouples software‘s from hardware and splits multi processor servers into more independent virtual hosts for better utilization of the hardware resources, allowing services to be distributed one per processor. In server consolidation many small physical servers are replaced by one large physical server to increase the utilization of expensive hardware resources, reducing the consumption of energy and emission of CO2 (Mueen and Abdul Rahman, 2010). Server virtualization complements overall IT consolidation projects by allowing firms to share capacity across multiple underutilized systems and shrink the hardware footprint of applications that cannot be completely eliminated.

2.2 Use Virtualization to Improve

Service Levels Data center managers should focus on reducing hardware and operational costs with virtual significant servers, yet overlook improvements to disaster recovery and faster time to market for applications. By offering improved service levels for virtualized servers, we can accelerate internal customers‘ migration to virtual infrastructure, while improving overall satisfaction with IT services.

2.3 Physical to Virtual Live Migration (P2V)

This is the most critical, time-consuming and painful operation when performed manually, since it includes cloning existing operating system and restoring it on an identical machine, but at the same time changing the whole underlying hardware, which can lead to driver reinstallation or possibly the dreadful blue screen of death.

To avoid these ambiguities, virtualization vendors started to offer different Physical To Virtual (P2V) migration utilities. This utility software speeds up the movement of operation and solves on the fly driver incompatibilities, by removing physical hardware dependencies from server operating systems and allowing them to be moved and recovered. Instead of having to perform scheduled hardware maintenance at some obscure hour over the weekend, server administrators can now live migrate a VM to another physical resource and perform physical server hardware maintenance in the middle of the business day. Virtuozzo for Windows 3.5.1 SWsoft itself introduced a Physical To Virtual (P2V) migration tool called VZP2V. This tool can remotely install P2V knowing machine administrative username and password.

2.4 Proper Management To Increase Utilization

Server consolidation increases the utilization ratio of underutilized volume servers from 10% to 50% or

even more by proper management of workloads to be virtualized to increase the productivity of data center and reduces the total cost of ownership. There is always a room for improvement, however, as many data centers leave a substantial amount of headroom on their virtual server hosts. Today, some data centers are consolidation the load of 5-10 Virtual Machines (Vms) on single server, while more experienced organizations are putting 25-30 VMs on a single server. Many administrators are reluctant to run servers at maximum capacity because they are concerned about the possibility of performance problems that could affect multiple applications simultaneously. In order to get to higher levels of hardware utilization, it is important to improve the administrators‘ visibility into the performance and availability of the virtual infrastructure with management tools designed for virtual servers. Active power management software can be used to help power your server infrastructure up and down depending on the demand for applications. This is particularly useful in virtual environments where live migration is used to consolidate VMs onto as few physical servers as necessary to maintain service levels, shutting down the rest.

3. Consolidate IT Processes

The best way to reduce hardware, software, labour and facilities costs is to unplug unneeded infrastructures. But it‘s a complex task that requires a lot of legwork and detailed information on your assets to do it right. You need to assess data center from all aspects and then categorize it into measurable units so that, consolidation can be applied and then benchmarking can be set properly to reduce the consumption of energy and emission of green house gases. IT consolidation involves the consolidation of servers, storage devices, applications running, operating systems.

Focus on Reducing Operational Cost

Virtualization increases the capability of already installed equipments by increasing their utilization ration and thus reduces the overall operational costs. Many data center managers tend measure the consolidation success rate by the percentage reduction in their IT budget, while it is important to note that consolidation success rates should be measured from percentage reduction in operational costs. Virtualization complements IT consolidation but cannot replace it. Even after virtualizing, you‘ll still be paying for the maintenance of the same number of application instances, even if they use less equipment to run. As a result, companies frequently struggle to reduce operational costs on the basis of virtualization alone.

3.1 Consolidate Storage into Networked Pools

Direct attached storage is usually blamed for data centers low storage utilization. However, networked storage can also suffer because of over-provisioning and isolated Storage Area Networks (SANs). You may already be paying for intelligent arrays with virtualization, thin provisioning, or deduplications features waiting to be turned on.

4. Improve Data Center Efficiency

Considering the power consumption in data centers, the main problem is the minimization of the peak power required to feed a completely utilized system. In contrast, the energy consumption is defined by the average power consumption over a period of time. Therefore, the actual energy consumption by a data center does not affect the cost of the infrastructure. On the other hand, it is reflected in the electricity cost consumed by the system during the period of operation, which is the main component of a data center's operating costs. Furthermore, in most data centers 50% of consumed energy never reaches the computing resources: it is consumed by the cooling facilities or dissipated in conversions within the

UPS and PDU systems. With the current tendency of continuously growing energy consumption and costs associated with it, the point when operating costs exceed the cost of computing resources themselves in few years can be reached soon. Therefore, it is crucial to develop and apply energyefficient resource management strategies in data centers. Upgrades data center power and cooling infrastructures so that energy efficiency can be achieved. There are many opportunities to reclaim capacity (and reduce electrical costs) in data center by making both small and large adjustments. Improving data center efficiency is especially important for large data centers.

4.1 Reduce Overall Electricity Consumption

Reducing data center electricity bill is usually the most tangible and easiest-tocalculate green IT goal. By implementing the proposed model will optimize and improved the overall energy performance of data center either on an absolute basis (usage is lower in the future than the present) or a relative basis (usage is lower in the future versus a "do-nothing" trend line projected from current levels).

4.2 Improve Utilization of IT Equipment

This is a related measure of IT efficiency, aimed at reducing not only electric power usage and spending but also future capital outlays on IT servers, storage and other gear. Higher utilization means managing the same IT workload on fewer servers, which in turn means less need for power, cooling and space and fewer new servers to buy going forward.

4.3 Prevent Hot & Cold Air Mixing

When hot exhaust air mixes with cold air, it increases the intake temperature of equipments installed in the data center. This means that it is necessary to set the temperatures even lower, to accept the intake temperatures. It is necessary to isolate the exhaust air with a hot aisle containment system or ceiling to reduce the load on cooling system and increase the power density of racks. Because it is relatively inexpensive, compared with new 10 infrastructures, facilities upgrades to prevent hot/cold air mixing were one of the top choices among the data centers. Before overhauling anything, start small improvements like eliminating under-floor obstructions to airflow, plugging cable cut outs and installing blanking panels in racks can improve the amount of air delivered to racks.

4.4 Improve Data Center Airflow

Without any new equipment or procedures, the IT team can improve circulation in the data center by moving boxes, unblocking air vents and generally tidying up. This can quickly translate into a lower power draw for the CRAC and related air handling equipment

4.5 Refresh Power & Cooling Infrastructure

Older, uninterruptable power supplies and power distribution units may have older, less efficient transformers that are responsible for a sizable portion of the wasted electricity in data center. It is important for data centers to replace these older systems with newer, more efficient. Most data center infrastructures are network oriented allowing collecting usage statistics from a variety of energy management software's.

5. Update IT Processes (Green Process)

Consolidation and virtualization helps to optimize hardware and software investments, reduce the number of systems being managed and free up or close some underutilized volume servers. However, IT

processes remain unchanged and probably a major source of IT inefficiency. Many data centers are implementing more formalized IT processes, while others suffer from IT processes that have too many steps and depends on manual labor to get them done. Therefore it now becomes obvious for data center managers to revise their IT processes to achieve green data centers.

5.2 Establish Critical It Processes & Upgrade Management Software

The focus should be on those processes that are most critical to running reliable and efficient IT services. In particular, problem management and incident management issues in data center followed by financial management and configuration management issues. IT processes ensures more reliable services, but with added records and data formalized processes don‘t get better efficiency because of the added overhead. The efficiency can be achieved by upgrading the system management tools that integrate with service desk software andprovide more task-level automation to free up administrators’ time.

CONCLUSION

Green IT is constantly becoming more relevant and many organizations are working towards reducing the carbon footprint of their data centers. This reduction in carbon footprint is achieved by reducing the data centers power consumption, which in turn results in savings for the organization. Many new techniques have been used to achieve this reduction in power. One of them is virtualization. it helps to consolidate multiple servers onto a few physical machines, which increases their utilization and decreases their power consumption.

This study presents perhaps an inaugural academic attempt to understand Green IT. However, as green issues continue to entice global debate, IT is expected to play a crucial role in both greening its operations and services and supporting a business‘s overall environmental sustainability objectives. Most CIOs and IT mangers are facing two conflicting demands. On the one hand, the growth of digital business has led to increasing demands for data centres. On the other hand, the rising cost of energy, its cleanliness and its availability are limiting the supply of energy to those data centres. This requires IT to turn to Green IT solutions. In this study we identified five concerns of Green IT economical, environmental, strategic, technological and social. These concerns are not mutually exclusive and they can underline the key motivation for building Green IT. We have also identified different dimensions of greening data centers by implementing green initiatives infrastructure in terms efficiency, of IT green technologies; support tools and supplanting tools.

The proposed green IT based model relates to implementing green business practice in general. However in this study, Green IT is conceptualised as a measure of data centers IT preparedness to be environmentally responsible and competitive. The five dimensions that make up the model can be combined in a variety of 11permutations to separate organisations that are successful in building Green IT from those that are less successful. Separately, the five attributes represents barriers to Green IT success. It encompasses as a solution for implementing green data centers. The proposed solution is mainly based on virtualization technology to overcome the issues and challenges of data centers like energy efficiency and CO2 emissions to reduce the effects of global warming.

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ISSN: 2231-2196 (Print) ISSN: 0975-5241 (Online)

TOLL LIKE RECEPTORS: THE IMMUNOMODULATORY AGENTS AND NOVEL TARGET OF IMMUNOTHERAPEUTIC RESEARCH

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ABSTRACT

Toll-like Receptors (TLRs), the evolutionarily conserved molecules are identified as the pattern recognition receptors (PRRs) in vertebrates and invertebrates which recognize the pathogenassociated molecular patterns (PAMPs). The TLRs signaling is via interactions with adaptor proteins including MyD88 and toll receptor associated activator of interferon (TRIF). They directly detect the pathogen invasion and induce either immuno-stimulatory or immunomodulatory biological response. This ability of TLRs to modulate the immune system has been taken in concern in recent studies to develop an adaptive immunotherapy against cancer and several other neurological disorders. Moreover, to trace their auxiliary therapeutic effects, the TLR agonists are now undergoing the extensive clinical investigation. This review discusses the therapeutic potential of TLRs as Immunostimulators and Immunomodulators. Alongside, the association of TLRs with autoimmune responses and human diseases is also explored.

Keywords: TLR, PRS, PAMP, Targeted therapy, autoimmune response

INTRODUCTION

The Toll-like receptors are so named because of their similarity to the Drosophila Toll receptor (Leimaitare et al., 1996). They recognize the pathogenassociated unique molecules such as the bacterial cell peptidoglycan wall (TLR2) components and lipopolysaccharide (TLR4) (Zhang et al., 2004). The dsRNA, ssRNA and nonmethylated Cytosine-Guanosine (CpG) DNA are also identified by TLR3, TLR7 and TLR9 respectively (Akira and Takeda, 2004; Takeda et al., 2003) (Fig.1). As a consequence, after activation of TLRs by said ligands the different cytokine and chemokines are produced which can further initiate the local inflammatory response to provide a first-line defense against pathogen invasion. The TLRs are mostly located on antigen presenting cells. Each of them, with the exception of TLR3, signals through the MyD88 (myeloid differentiation88 gene) dependent pathway, initiated by the MyD88 adaptor protein (Broad et al., 2007). The MyD88 recruitment at TLRs instigates the formation of Imterleukin-1 (IL-1) receptor associated kinase (IRAK) complex (Fig.2). Four members of this family have been identified: IRAK-1, IRAK-2, IRAK-4 and IRAK-M (Björkbacka, 2006). Knockout mice for IRAK-4 had completely abolished responses to TLR2, TLR3, TLR4 and TLR9 showing that this molecule is essential for TLR signaling (Pasterkamp et al., 2004). Also, the MyD88 deficient cells show the increased expression of costimulatory molecules, such as CD80 and CD86 to induce dendritic cell maturation in the absence of MyD88 dependent pathway.

Formation of IRAK complex further result in phosphorylation of IKKa/b, activation of the transcription factors NFkB, IRF1, and IRF7, and generation of the proinflammatory cytokines IL-6 and TNFα and others (Takeuchi et al., 200; Brenda et al., 2008). While TLR3 signals through the MyD88 independent pathway, initiated by the TRIF adaptor molecule (Broad et al., 2007) which unlike to others initiates the phosphorylation of IKKe and activates the transcription factors IRF3 and IRF7 to generate the anti-viral molecules such as Interferon β (IFNβ) (Brenda et al., 2008). Amongst TLRs, only TLR4 can utilize either of these pathways (Fig-2). The TLRs are proved to be a key link between obesity, insulin resistance, and cardiovascular disease. Pharmacologic approaches to modify the activity of the TLRs may therefore have favorable influences on the atherosclerotic disease process and other cardiovascular disorders (Boekholdt et al., 2008).

TLRs AND TH RESPONSE

Since, TLRs are widely expressed on immune cells such as Dendritic Cells (Dcs), monocytes, mast cells, neutrophils, B cells, endothelial cells and fibroblasts therefore; they activate these cells to produce IL-12 and IFN-α to mount the Th1 responses. However, apart from the professional antigen presenting cells (APCs), TLRs are also found expressed on non-immune cells such as mesangial, astrocytes, uterine epithelial and fibroblasts cells (Lutz and Schuler 2002). Role of TLRs in the development of classic Th2 responses is still debatable. Though, highly purified P. gingivalis LPS, a putative TLR2 ligand (Methe et al., 2005) Pam-3-cys, a synthetic TLR2 ligand and Schistosomal Egg Antigen (SEA) have been shown to induce the Th2 responses (Sakata et al., 2007).

TLRs AS IMMUNOSTIMULATORS

TLRs being organism-wide sensor system play a frontline effector role in host defense. Hitherto, many TLR agonists have been developed to be used as vaccine adjuvants to stimulate & enhance the antigen specific memory response and circumvent the booster burden. Recently, the utilization of TLR agonists against neural cancer has been an emerging strategy to stimulate the tumor specific natural adaptive anti-tumor immune response. In this approach, specific timorous area is only targeted along with protection of normal brain structures. Several TLR agonists have been investigated in this regard.

One particular candidate the Imiquimod has got most attention in cancer immunotherapy. It is a synthetic TLR7 agonist that has been given the Food & Drug Administration (FDA) approval as a topical treatment for Herpes Sarcoma Virus (HSV)-2 lesions (Prins et al., 2006). In a recent study, the topical application of Imiquimod has been shown to decrease intracranial tumor burden in a malignant melanomic mouse model (Prins et al., 2006). It is believed that the said effect was shown due to prolonged existence of antigen-pulsed dendritic cells and improved $CD8^+$ priming. However, a prolonged Imiquimod treatment has also been reported the increased hemorrhaging inflammation-induced mortality.

Lipopolysaccharide (LPS), a potent agonist of TLR4 has also been investigated for its anti-tumor immune efficacy. In a study by Won et al (2003), the LPS have been shown to decrease the mean tumor mass of primary subcutaneous Glioblastoma Multiforme (GM) tumors in induced mouse model. Supportively, the LPS administered mice bearing intracranial GM tumors have been shown the increased survival thanTLR4 knockout mice of the same group. The observations suggested that the LPS cytotoxicity is however insufficient to clear the tumors but certainly may act as a tumor-specific immune adjuvant (Chicoine et al., 2007).

The chemotherapeutic use of one more agonist of TLR9, the nonmethylated CpG oligodeoxynucleotides have also got attraction and shown the great promise. It has been demonstrated that the intratumoral CpG administration in mice and rats with subcutaneous and intracranial neuroblastoma tumors increases the survival time and protects against secondary tumor challenge (Carpentier et al., 1999). It induces the apoptosis of intracranial glioblastoma cells (El Andaloussi et al., 2006). TLR9 is chiefly expressed by glial cells in mice but restricted to the B cells and plasmacytoid dendritic cells in healthy humans subjects (Iwasaki et al., 2004). A Phase II clinical trial is in progress to explore the therapeutic potential of said ligand into generation of a specific anti-tumor immune response in patients with brain tumors.

TLRs AS IMMUNOMODULATORS

In addition to immunostimulation, immunosuppressive properties of TLRs are also exploited to develop immunotherapy against neurological disorders. Such immunosuppressive therapies are based on the phenomena of ―tolerance‖, where moderate pre-exposure of deleterious stimulus potentiate the animals to show the tolerance against subsequent intensive exposure of the same. For instance, the mild pretreatment of LPS can protect an animal from detrimental effects during subsequent higher exposure of the same. Supportively, a study by Tasaki et al (1997) demonstrated that the systemic administration of low dose LPS subsequently render the tolerance in hypertensive rats to ischemic brain damage induced by middle cerebral artery occlusion (MCAO). The mechanism behind is believed that the inflammatory response induced during pretreatment of LPS enhances the blood perfusion towards ischemic area at the time of ischemia and afterwards (Kunz et al., 2007; Dawson et al., 1997).

Moreover, LPS pretreatment has also been reported to protect brain against cytotoxic effects of TNFα after cerebral ischemia (Rosenwieg et al., 2004). It is observed that the LPS tolerant Cells possess deficient ability to generate TNFα in response to TLR4 activation. These cells unlike to naïve cells, do not recruit MyD88 to TLR4, and fails to activate IRAK-1and NFkB thereby leading to blockage in TNFα expression (Medvedev et al., 2002). Since, Dendritic Cells (DC) contain TLR9 thus it is observed that after exposure of DCs from TLR9 agonists (with or without antigen), various pro-inflammatory cytokines and chemokines were secreted which further activated and some time suppressed (caused due to specific cytokine viz. IL-6) to the effector T cells (Th1 and/or CTL cells) response (Pasare and Medzhitov, 2003) (Fig 3).

ROLE OF TLRs' IN AUTOIMMUNE RESPONSE

The autoimmunity is a consequence of unbridled proliferation of auto-reactive immune cells along with defects in the maintenance of tolerance (Yamada et al., 2005). Several evidences have now established that TLRs contribute to the development of autoimmunity (Suzuki et al., 2002). The virus induced IFN-α, whose effect can be mediated via TLRs 3, 7 and 9, contribute significantly in the pathogenesis of type I diabetes mellitus and Systemic Lupus Erythematosus (Kobayashi et al., 2002). Moreover, viral dsRNA (double stranded RNA) can bind to TLR3 and activate NF-κB which induces the formation of apoptotic bodies that further promotes plasmacytoid DCs to produce IFN-α (Kawai, 2001). B cells as professional antigen presenting cells express both TLR7 and TLR9. Out of which, TLR 9 are reported to break the tolerance of auto-reactive B cells through binding to hypomethylated CpG-containing DNAs, which are present in the mammalian DNA itself (Doyle et al., 2002). These regions, which may be the derivatives of apoptotic or necrotic cells, form a complex with anti-DNA IgG autoantibodies and stimulate B cells via BCR and TLR 9 (Kaisho et al., 2001).

POSSIBLE ROLE OF TLRs IN HUMAN DISEASES

TLRs being active immunomediators recognize the various endogenous proteins that are often released in response to stress or tissue damage and variably found at the sites of chronic inflammation. These may be heat shock proteins (hsp) 60, 70, 96, extra domain A-containing fibronectin fragments, hyaluronan fragments, fibrinogen, β-defensins, oxidized lowdensity lipoprotein and heparan sulfate(Leadbetter et al., 2002). This ability of TLRs to interact with inflammatory cytokines has caused them to be investigated for their role in Rheumatoid Arthritis, Crohn's Colitis, disease, Ulcerative Psoriasis, Chronic Obstructive Pulmonary Disease (COPD) and Atherosclerosis (Anders et al., 2005). As evidence, the polymorphisms in TLR9 have been shown to be associated with an increased risk of Systemic Lupus Erythematosus (Seibl et al., 2004). In a study by Lynn et al. (2003) the TLRs inhibition with hsp10 has suggested the beneficial effect on the symptoms of rheumatoid arthritis (RA). Moreover, mutated TLR4 have been found associated with a decreased response to inhaled lipopolysaccaride and increased susceptibility to severe bacterial infections and bacteremia (Kawakami et al., 2008). Since, the numbers of TLRs are involved in different types of infection and each has differing immune and inflammatory cascades therefore, mutations in these genes have provided the subject to study the body's response to endogenous and exogenous ligands (Steinman, 2006). In future, these may be the molecular targets which can ably interfere to the development of septic shock syndrome, while maintaining some natural immune response to pathologic bacteria (Doherty et al., 2006).

CONCLUSION & FUTURE PERSPECTIVES

Above discussion has demonstrated the TLRs as an immunomodulatory agent who can generate the protection against cancer and suppress the damaging inflammatory responses. Captivatingly, the ability of TLRs to activate tumor specific lymphocytes has been translated into antitumor immunotherapy in recent studies. Also, the TLR agonists based immunostimulation has been proven its success in treating the neurological disorders. Though, owing to systemic cytokine induction, the systemic use of TLR agonists may be restricted by doselimiting toxicities but combinatorial approaches with conventional therapies such as chemotherapy may be promising. However, pharmacological interventions using TLRs antagonists are in infancy but hold much promise for future success. Therefore, with increasing evidences of active role in initiation and maintenance of immune response, the TLRs can be an attractive drug targets for regulating the immune terror.

ACKNOWLEDGEMENT

Authors acknowledge the kind support of Dr. Vinod Singh, Associate Professor, Department of Microbiology, Barkatullah University, Bhopal, MP, India during preparation of the manuscript.

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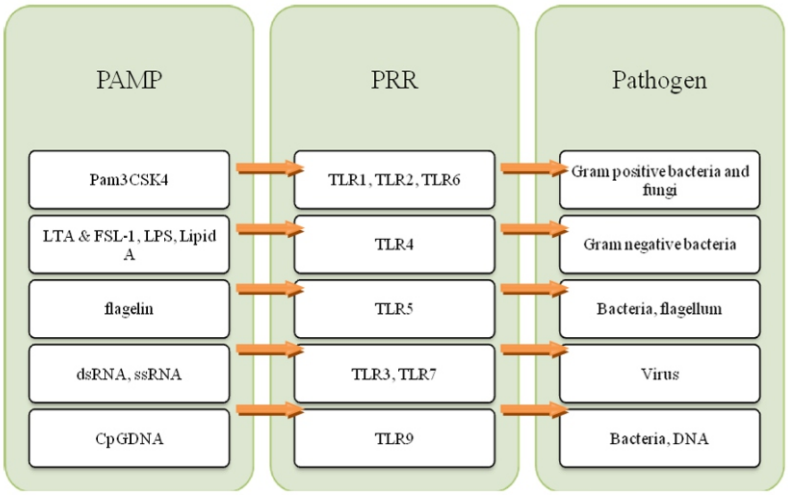

Fig. 1: Relational representation of Pathogen-Associated Molecular Pattern (PAMPs) with Pattern Recognition Receptors (PRRs) and pathogens.

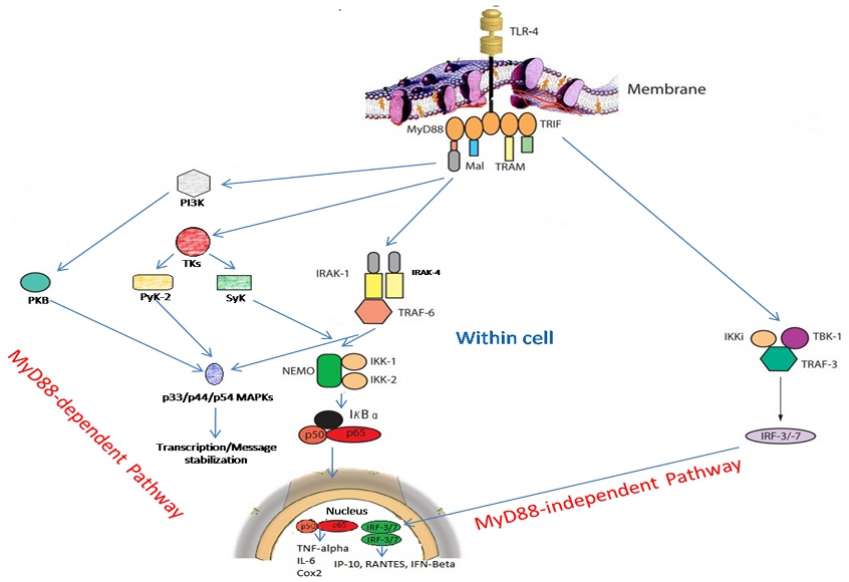

Fig. 2: MyD88 dependent and independent pathway of TLR signaling.

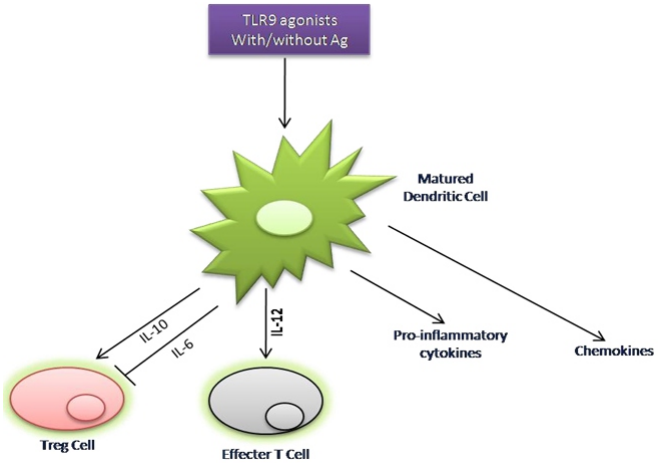

Fig. 3: TLR9 mediated cytokine and chemokines secretion from Dendritic Cells and consequent effector and suppressive immune response.

ISSN: 2231-2196 (Print) ISSN: 0975-5241 (Online)

ANTI-MICROBIAL EFFECT OF AZADIRACHTA INDICA AND OCIMUM GRATISSIMUM AGAINST ASPERGILLUS NIGER CAUSING STORAGE ROT OF GARCINIA KOLA

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ABSTRACT

Three fungi Aspergillus niger, Penicillium expansum and P. digitatum were isolated from seeds of bitter kola (Garcinia kola) obtained from market stalls in Umuahia, Abia State, Nigeria but A. niger was found pathogenic during pathogenicity test. The pathogenic organism was subjected to cold water leaf extracts of A. indica (Neem) and O. gratissimum (Sweet Basil) which gave a growth inhibition of 85.35 % and 66.74 % respectively after five days of incubation. The inhibitory effects of the extracts against the pathogen were more with A. indica (Neem) than O. gratissimum and this increased with the incubation period. Cold water extracts of these plants could be exploited as pesticides of plant origin in the control of post-harvest microbial deterioration of seeds of G. kola incited by A. niger.

INTRODUCTION

Garcinia kola commonly referred to as bitter kola due to its bitter taste is highly medicinal (Uko et. al., 2001) and usually found in the tropical rain forest region of West and Central Africa (Gill, 1998). Seeds of G. kola are highly nutritious (Adeyaye et. al., 2007) and several medicinal and anti-microbial attributes like treatment of cough and hepatitis, snake repellant, and chest medicine have been assigned to the seeds of G. kola (Iwu, 1993). Post-harvest microbial deterioration of G. kola seeds has been observed during storage and this has reduced both the nutritional and market value of the seeds. Extending the shelf-life of G. kola seeds during storage will ensure availability of the seeds and continuous production (Korie, 1996). Depletion of important forest trees like G. kola in rainforest regions as well as the medicinal values of G. kola seeds which have increased dramatically in the last decade (Smith, et. al., 1996) makes it imperative for an increased search for methods of preserving seeds of G. kola. Available literature indicates that not much work has been done on the microbial deterioration of G. kola seeds and their control in storage.

Studies on anti-microbial activity of plant extracts have shown the significance of natural chemicals as possible source of non-phytotoxic, systemic and easily biodegradable alternative to synthetic pesticides which are not only hazardous to both the farmer and the environment but scarce and expensive when available (Amadioha, 1998, 2003; Olojede et. al., 1993). Extracts of A. indica (Neem) and O. gratissimum have been reported to be very effective in the control of storage disease of some other agricultural products (Amadioha and Obi, 1999). The effectiveness of leaf extracts of these plants in the control of storage rot disease of seeds of G. kola incited by A. niger is presented in this paper.

MATERIALS AND METHODS

Source of Garcinia kola: Matured healthy (uninfected) and infected seeds of G. kola were obtained from open market stalls at Oboro, Umudike and Ndume in Umuahia, Abia State, Nigeria. The infected samples were collected in sterile polyethylene bags and taken to the laboratory for isolation.

Culture Medium: Potato Dextrose Agar (PDA) was used in the isolation of the fungi associated with the rot of G. kola seeds. Thirty-nine grammes of PDA was added to one litre of distilled water chloramphenicol, containing thoroughly 1000mg of mixed and dispensed into 500ml conical flasks and then plugged with cotton wool and capped with aluminum foil before sterilization for 15 minutes in an autoclave set at 121oC (105kg/cm^2). The sterilized medium (20ml) was dispensed into sterile disposable Petri dishes (9 cm diameter).

Isolation and Identification of Isolates: Infected G. kola seeds were washed in running tap water and distilled water before surface sterilizing with 70% ethanol for 10 seconds to prevent any surface contaminant that may interfere with the isolation and identification of rot causing organisms. Infected tissues (5cm) were removed and plated on the chloramphenicol amended culture medium (PDA) in Petri dishes and incubated for 5 days at room temperature (27^{o}C). Three isolates were identified, A. niger, P. expansum and P. digitatum based on their morphological characteristics and reference to Rossman et. al. (1997).

Pathogenicity Test: The method described by Amadioha (1998) was used. Healthy (uninfected) G. kola seeds were disinfected with70% ethanol and rinsed with distilled water.With the aid of a cork borer (4 mm diameter), a 4 mm diameter disc was removed and a 4 mm diameter disc of the 5- day old culture of the isolates were each used to plug each hole. The disc removed from the healthy G. kola seed was replaced after 1 mm had been cut off to compensate the thickness of the isolate and then sealed with Vaseline. Each inoculated seed was placed in a micro-humidity chamber (a small polyethylene bag containing cotton wool soaked with distilled water) and incubated for 5 days. Following the development of rot symptoms, reisolation was carried out to confirm that the isolates were the same as the original isolates introduced. The organism that caused rot and found to possess the same characteristics features with the original isolate (A. niger) was confirmed as pathogen whereas the Penicillium species that did not cause any rot symptom during pathogenicity test were regarded as nonpathogens or saprophytes and discarded.

Effect of extracts of Azadirachta indica and Ocimum gratissimum on the radial growth of Aspergillus niger : Fresh leaves of A. indica (Neem) and O. gratissimum were washed in running tap water and sterile distilled water, airdried at 27oC, weighed (100g) and ground in a sterile mortar with a piston. The paste was put in 250ml beaker and 100ml of distilled water was added, stirred vigorously and allowed to stand for 1 hr and then filtered through four folds of sterile cheese cloth to obtain a cold water extract of each of the test plants.

The effect of the extracts on the radial growth of A. niger was determined using the poisoned food technique described by Amadioha (2002). The extract-PDA medium was prepared by spreading 0.5ml of each extract separately on the surface of the solidified PDA contained in Petri-dishes to form a thin film. The control was 0.5ml of sterile distilled water. A disc (5mm diameter) of 5 day old culture of A. niger was cut from the growing end of its pure culture and placed in the centre of a Petri-dish with three replicates of each treatment. The treated plates and control were then incubated at 27oC and radial growth in each treated plate and control experiment was measured after 4 days when the fungal growth in the control experiment had reached the periphery of the Petri-dishes. The experiments were repeated four times and mean values obtained. The percentage growth inhibition was calculated using the formula adopted by Amadioha (2003):

$$\% \text{ growth inhibition} = \frac{dc - dt}{dc} \times \frac{100}{1}$$

Where dc – diameter of fungal colony in control experiment
dt - diameter of fungal colony in the treatment.

RESULTS AND DISCUSION

Isolation and identification of pathogenic organism:

Three fungi were isolated from dead remains of G. kola, A. niger, P. expansum and P. digitatum but A. niger was pathogenic during the pathogenicity test. The frequency of association is shown in Table 1. A. niger was used as test organism throughout the course of this experiment based on its frequency of occurrence and level of pahogenicity. Several pathogenic organisms have been associated with the postharvest microbial deterioration of stored agricultural products (Amadioha and Adisa, 1999; Markson et. al., 2010). Booth (1974) and Coursey (1967) attributed attack by microorganisms as the most serious cause of post-harvest loss of stored products. In the present study, A. niger caused appreciable rot of G. kola seeds in storage whereas the Penicillium spp were found to be saprophytic or nonpathogenic. This is apparently the first report in Nigeria showing A. niger as the most virulent and frequently encountered pathogen inciting rot of G. kola seeds in storage.

Effects of Azadirachta indica and Ocimum gratissimum leaf extracts on the radial growth of Aspergillus niger in vitro: Potential use of extracts of plant origin in plant disease control has been emphasized (Amadioha, 2000) but very little or no work has been done on the use of plant products against storage rot of G. kola seeds caused by A. niger. Results of the effects of A. indica (Neem) and O. gratissimum leaf extracts on A. niger showed that the plant extracts significantly inhibited the radial growth of test fungus in vitro when compared with the control experiment, suggesting the presence of antifungal substances in the tissues of the test plants. A. indica was more effective than O. gratissium in reducing the radial growth of the pathogen in culture. The differences in toxicity could be attributed to the solubility of the active principles/compounds of the test plants in the extracting solvent and or, the presence of inhibitors to the active principle (Amadioha, 2001), with higher solubility of the active compounds of A. indica than O. gratissium. The differences in active principles/compounds of the test plants and their solubility in the extracting solvents could be influenced by the age of the plant and the extracting solvent (Qasem and Abu-Blan, 1996). A. indica, has been reported to be effective as insecticide (Emosairue and Ukeh, 1990), bird repellent (Mason and Mathew, 1996) and as fungicide both in the field and storage (Amadioha, 2001, 2002; Amadioha and Obi. 1998).

The current investigation showed that the percentage growth inhibition of the pathogen in culture increased with period of incubation (Table 2), indicating the presence and persistence of the anti-fungal activity of the extracts of the test plants which were retained against the pathogen for the whole period of incubation. The test plants are common medicinal plants in Nigeria that could be exploited as extract of plant origin for the control of storage rot disease of G. kola seeds incited by A. niger.

CONCLUSION

A survey of three market stalls in Umuahia Abia State, Nigeria showed that A. niger was a major pathogenic organism causing storage rot of G. kola seeds. In vitro investigations revealed that cold water crude leaf extracts of A. indica (Neem) and O. gratissimum inhibited the radial growth of A. niger in culture suggesting the presence of anti-microbial substances in the tissues of these plants. The extracts of A. indica (Neem) and O. gratissimum could be exploited as pesticides of plant origin in the control of

post-harvest microbial deterioration of G. kola seeds caused by A. niger.

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Table 1: Frequency of occurrence of Aspergillus niger and Penicillium species in rotted Gacinia kola seeds from three market stalls in Umuahia.

Market	Frequency of occurrence (%)		
	Aspergillus niger	*Penicillium expansum*	*P. digitatum*
Oboro	82	52	45
Ndume	71	47	30
Umudike	65	50	40

Table 2: Effect of extracts of Azadirachta indica and Ocimum gratissimum on the radial growth of Aspergillus niger in culture.

Incubation period (days)	Growth inhibition (%)		
	Azadirachta indica	*Ocimum gratissimum*	Control
1	60.50	27.97	0
2	70.97	57.81	0
3	83.50	59.41	0
4	84.37	65.26	0
5	85.35	66.74	0

ISSN: 2231-2196 (Print) ISSN: 0975-5241 (Online)

COMPARATIVE STUDY OF EFFICACY OF VASTUS MEDIALIS OBLIQUUS Vs RECTUS FEMORIS USING OPEN KINEMATIC AND CLOSED KINEMATIC EXERCISES IN PATELLOFEMORAL PAIN SYNDROME

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ABSTRACT

Background: Patellofemoral pain syndrome (PFPS) is often treated conservatively with voluntary exercise for the Quadriceps femoris. Nevertheless, a substantial percentage of patients remain symptomatic. Although exercise seems a crucial element for treatment, it may serve to increase patellar irritation with the resulting dilemma that patients exercising the muscles may be simultaneously irritating the knee. Patients with PFPS have been using quadriceps strengthening exercises with varying results on muscle strength and pain. However, there are various problems associated with these forms of traditional quadriceps strengthening exercises. This study sought to explore the effects of progressive functional retraining of Vastus Medialis Obliquus (VMO) in the context of PFPS. **Purpose:** To compare the efficacy of strengthening of VMO Vs Rectus femoris (RF) using open kinematic and closed kinematic chain exercises in PFPS. **Methods:** This study was conducted at Yenepoya Medical College Hospital, Mangalore. Forty subjects with anterior knee pain fulfilling the inclusion criteria were randomly assigned to two groups with the mean age of 25.85 in group 1 and 27.65 in group 2. Group 1 received RF strengthening exercises. Group 2 received strengthening of VMO. Visual Analog Scale (VAS) and anterior knee Pain Scale were noted before and after the interventions. (i.e. either RF strengthening or strengthening of VMO). **Results:** After 2weeks of intervention in Group 1 there was a significant increase Anterior knee pain scale(AKPS) with mean difference of 4.95 and VMO co-ordination test status. There was also a significant decrease in the VAS scale and with mean diff of 0.5 , whereas in Group 2, AKPS with mean diff of -23.8 , VAS with the mean diff of 4.5 were all highly significant and there was a increase in VMO co-ordination test but statistically not significant. **Conclusion:** Strengthening of VMO clinically as well as statistically suggest that strengthening of VMO is more effective than the traditional strengthening of RF in patients with PFPS.

Key words: patello femoral pain syndrome, anterior knee pain scale, strengthening, visual analogue scale.

INTRODUCTION

Patellofemoral pain syndrome (PFPS) refers to the clinical presentation of anterior knee pain related to changes in the patellofemoral joint. This can be brought on by prolonged sitting (the so called 'theatre goer's sign'); by ascending and descending stairs, squatting, kneeling and by athletic activity. Clinical assessment of patients reveals a general paucity of abnormal physical findings. PFPS is considered to have an uncertain etiology with numerous theories propounded, including tightness of soft tissue and

periarticular structures, patellofemoral malalignment and maltracking, tibial torsion and gait abnormalities. These commonly sited theories for PFPS have recently been supplemented by theories about nerve damage in the lateral retinaculum and patellar bone hypertension. Another proposal is that PFPS may develop due to a dysfunction of the extensor mechanism described to be due to generalized quadriceps weakness and wasting, decreased eccentric function, or differences in the activation patterns of the Vastus Medialis. To date, it is still unknown if the quadriceps dysfunction causes the patellar pain or the pain causes the dysfunction1. Recently, based on human and cadaveric studies, authors have reported that the vastus medialis is composed of sets of fibers namely proximal, middle and distal fibers. The proximal and middle fibers get attached to the tendon common to the rectus femoris and the distal fibers get inserted into the medial aspect of the patella, which resists the valgus vector because of the _Q' angle thereby controlling the patellar tracking movements2. During voluntary ankle movements, anticipatory postural adjustments are initiated at the knee which co activates the Vastus Lateralis (VL) and the Vastus Medialis Obliquus (VMO) and this guides the normal patellar tracking. Studies have reported that there is a 5 ms delay in the VMO activation when compared to the VL. This shows that there is an altered VMO recruitment and change in the motor control in subjects with PFPS that should be considered for effective rehabilitation3. In the analysis of patellofemoral joint reaction forces the results showed an increase in the patellofemoral joint reaction forces (PFJRF) with increasing knee flexion in Closed Kinetic Chain (CKC), whereas in Open Kinetic Chain (OKC) it increased from 90º of knee flexion to knee extension. Therefore, it is important to consider these specific ranges of knee motion in the rehabilitation of PFPS 4 The strength of evidence for routine terminal range knee extension exercises in OKC and squatting exercises in CKC for Vastus medialis strengthening is insufficient. Hence there is a need to identify efficient techniques in the rehabilitation of PFPS for improving the motor control around the knee considering rectus femoris which has the main attachment over the base of patella, correcting the abnormal patellar tracking, reversing the delayed onset of the VMO and decreasing the PFJRF for better outcomes. As there are not much studies done on rectus femoris in PFPS, this we have taken as a consideration and progressed with a study on RF and VMO in PFPS.

METHOD

Forty subjects aged between 20 to 40years with PFPS referred for Physiotherapy at Yenepoya medical college hospital were enrolled in the study. The inclusion criteria were (a) Anterior, peripatellar or Retro patellar knee pain more than 3months at least two of prolonged sitting, stairs, squatting, running, hopping/jumping.(b)insidious kneeling and onset of symptoms unrelated to traumatic incident (c)average pain level of 5cm or more than that on a VAS scale (d)age 40years or less to avoid degerative changes in Patellofemoral joint (e)symptoms for atleast 2weeks. Subjects were excluded if they had (a)signs and symptoms of their co-existing pathology (b)recent history of knee surgeries (c) evidence of OA changes (d)history of patellar subluxation or dislocation (e)ligamentous instability,meniscal lesion,plica syndrome (f)pregnancy (g)patellar tendon pathology (h)referred pain from the spine (i)knee joint effusion (j)illiteracy/inability to understand and answer questionnaires. Subjects were randomly allocated to the group 1 and group 2 using simple randomization with provided written consent informed consent.

Procedure:

A total of 40 subjects were randomly assigned to both the groups, Group 1 (Rectus femoris Strengthening) having n = 20 and Group 2 (VMO Strengthening) having n = 20. All the subjects assessed for their cause of knee pain. When the evaluation concluded that the subjects are victims of

Patellofemoral pain syndrome (PFPS), an informed consent was obtained from the subjects for the purpose of this study. The subject‘s intensity of pain is documented using a VAS scale for the usual and worst pain. The subject is then provided with an Anterior Knee Pain Scale, which consisted of a questionnaire. The questions on the pain scale are explained in detail and the subject is then asked to choose the most appropriate alternative. The Visual analogue scale (VAS) consisted of a simple 10 cm line, one end being marked with a zero and the other end being marked with a ten. The points zero and ten indicated the pain level, zero representing no pain and ten indicating the worst and most severe type of pain. All the other numbers from one to ten would indicate a gradual increment in the pain level. The subject was asked to indicate on the line where the pain is, in relation to the two extremes. The subject is then expected to choose a number on the scale rating his/her own pain appropriately. The Anterior Knee Pain Scale is a 13 item questionnaire which includes questions that ask the subject to describe their ability during walking, stair climbing, squatting, running, prolonged sitting, hoping and bar jumping. It instructs the subject to circle the latest choice, which corresponds to their knee symptoms. The focus of the anterior knee pain scale (AKPS) on symptoms may lead the subject to emphasize pain rather than function. The scale consists of discrete categories within which each item is weighted and responses are summed to provide an overall index in which 100 represents no disability In the Vastus medialis (VMO) co-ordination test, the subject is in the supine lying position. The examiner places the fist below the knee and the subject is asked to extend the knee slowly without pressing down or lifting the knee away. The test is considered positive when there is a lack of a coordinated full knee extension. After the pain scale questionnaire was completed, physiotherapy intervention was commenced for the subjects.

Subjects in Group 1 received strengthening exercises of rectus femoris for 2 weeks. Rectus femoris strengthening included OKC which avoids terminal knee extension and CKC which avoids excessive knee flexion exercises. Knee extension exercises in OKC are given to the subject who is in a seated position in an extension curl pulley system. 10-RM is taken by a maximum amount of weight lifted 10 times through the prescribed range. An initial weight is reasonably chosen and based on that 10-RM was calculated a rest interval of 5 minutes should be given prior to attempting to lift the next heavier weight. CKC exercises include mini squatting with 0° to 40° of knee flexion with the subject standing against a Swiss ball supported on a wall. It was performed in 3 sets with each set comprising of 10 repetitions. Step exercises were started after the subject could descend 5 steps without pain. Subjects in Group 2 received strengthening of vastus medialis obliquus for 2 weeks. OKC exercises were given in sitting with the knee at 90° flexion. 10 RM was taken by a maximum amount of weight lifted 10times through full knee extension with lower leg lateral rotation to facilitate maximum contraction of the vastus medialis obliquus. An initial weight is reasonably chosen and based on that 10RM is calculated and then knee extension is performed till 0°. CKC exercises were done by using step-down exercises where the subjects were made to step down from the step which is of 25cms in height. When the subject could complete 5 step downs from a 25 cm step without pain, the step down exercise and VMO retraining with isometric hip abduction in standing and stretching of tightened soft tissue structures are included. Outcome was measured at the end of 2nd week.

Outcome measures: All the data on the scales of Visual analogue scale (VAS), Anterior knee pain scale (AKPS) and Vastus medialis obliqqus (VMO) Co-ordination were obtained before the initiation of the treatment and 2 weeks after the completion of the treatment. Anterior knee pain scale (AKPS) questionnaire was used with a set of questions based on the symptoms, the results of which were summed up and the scores were taken. Similarly, Visual analogue scale (VAS) was used to document the pain.

Data analysis: The software programme used for data analysis was SPSS Ven15. Microsoft Excel was used for graphs. Demographic data of anterior knee pain scale (AKPS) and Visual analogue scale (VAS) status of both the groups were analyzed by using paired't' test. Probability values of less than 0.05 were considered statistically significant. Demographic data of Vastus medialis obliquus (VMO) Coordination test status was analyzed by using the 'Fishers test'. Probability values of less than 0.05 were considered significant.

RESULTS

When subjects performed rapid strengthening exercises for rectus femoris under group 1 and VMO under group 2, there were differences in both the groups but more significantly in group 2. In table 2 comparisons are done between Pre and Post Anterior knee pain scale (AKPS) within group 1(Rectus femoris strengthening). Pre Anterior knee pain scale (AKPS) had 20 subjects having mean of 72.65 (+/- 15.45) where Post Anterior knee pain scale(AKPS) had 20 subjects having mean of 77.60 (+/-14.01) and a mean difference of -4.95 with p-value of 0.295 which is not significant. Group 2 analysis showed Pre Anterior knee pain scale(AKPS) with 20 subjects having mean of 65.90 (+/- 13.19) where Post Anterior knee pain scale (AKPS) had 20 subjects having mean of 89.70 (+/- 6.67) and a mean difference of -23.8 with a significant p-value of 0.0001.

Table 1 . Comparison between Pre and Post Anterior knee pain scale (AKPS) status between Group 1(Rectus femoris strengthening exercises) and group2 (Vastus Medialis obliquus strengthening exercises)

GROUP 1	N	MEAN	S.D	M.DIF	t	p	GROUP 2	N	MEAN	S.D	M.DIF	t	p
Pre AKPS	20	72.65	15.455	-4.95	1.061	.295	Pre AKPS	20	65.90	13.191	-23.8	7.20	.0001
Post.AKPS	20	77.60	14.017				Post.AKPS	20	89.70	6.674			

Table 2 . Comparison between Pre and Post Visual analogue scale (VAS) status between Group 1(Rectus femoris strengthening exercises) and group2 (Vastus Medialis obliquus strengthening exercises)

GROUP 1	N	MEAN	S.D	M.DIF	t	p	GROUP 2	N	MEAN	S.D	M.DIF	t	p
Pre VAS	20	5.40	2.010	0.5	.794	.431	PreVAS	20	6.50	2.417	4.5	6.78	.0001
Post.VAS	20	4.90	1.971				PostVAS	20	2.00	1.717			

Table 2 shows comparison between Pre and Post Visual analogue scale(VAS) within group 1(rectus femoris strengthening). Pre visual analogue scale (VAS) had a mean of 5.40 (+/- 2.01) and Post Visual analogue scale(VAS) had a mean of 4.90 (+/- 1.97) with a mean difference of -0.5 and p-value of 0.794 which is not significant. Within group analysis of group 2 (vastus medialis strengthening) shows a mean of 6.50 (+/- 2.41) for Pre Visual analogue scale(VAS) and post VAS had a mean of 2.00 (+/- 1.71) with a mean difference of 4.5 and a highly significant pvalue of 0.0001.

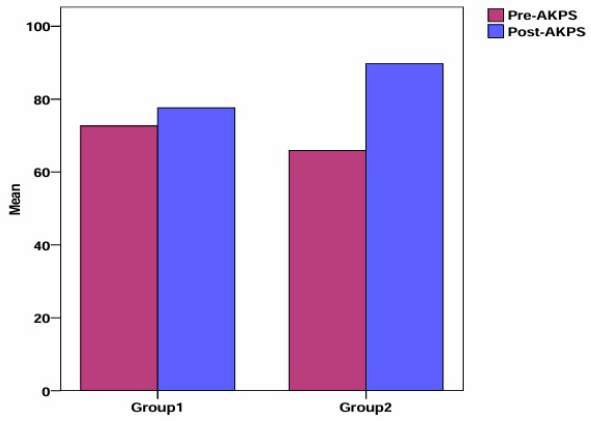

Figure 1. Comparison of Pre And Post AKPS Status between Group 1 (rectus femoris strengthening) and group 2(vastus medialis obliquus strengthening)

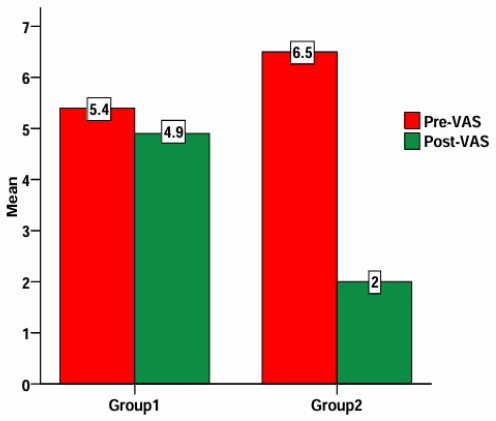

Figure 2. Comparison of Pre And Post VAS Status between Group 1 (rectus femoris strengthening) and group 2(vastus medialis obliquus strengthening)

Table 3. Comparison between pre and post Vastus medialis obliquus (VMO) Co-ordination test among group 1(rectus femoris strengthening) group 2 (vastus medialis oblique strengthening)

	Positive	Negative	Total
Group 1 count	14	6	20
% within group	70.0%	30.0%	100.0%
Group 2 count	17	3	20
% within group	85.0%	15.0%	100.o%
Total count	31	9	40
%within group	77.5%	22.5%	100.0%

Table 3 shows comparing percentage between Pre and Post Vastus medialis obliquusV(MO) co-ordination test within group 1(rectus femoris strengthening) and group 2(vastus medialis obliquus strengthening) .Group 1 has 70.0% of positive reading and 30.0% of negative reading where as group 2 has 85.0% of positive reading and 15.0% of negative reading. So comparing group 1 with group 2 there is a difference in VMO co-ordination test status which is not significant statistically.

DISCUSSION

At the end of our study, strengthening of the VMO showed very good improvement in PFPS subjects than in strengthening of rectus femoris muscle and by this it is clear that Rectus femoris strengthening is not much effective in patients with patellofemoral pain syndrome. There was also a reduction in VAS status in subjects under VMO strengthening programme than in the rectus femoris strengthening programme. Even in the Anterior knee pain scale questionnaire there was an improved scoring in group 2 with VMO strengthening programme at the end of 2week programme up to 100%, but there was no any significant change in the VMO Co-ordination test, so this test cannot be used as an assessment tool in the subjects with Patellofemoral pain syndrome.

Several studies suggest that VMO dysfunction could lead to PFPS, so for effective rehabilitation one has to concentrate on the strengthening of VMO. The tension developed in VMO acts both medial and

posterior aspect of knee joint and is known to resist lateral patellar displacement. Clinical observation linking loss of active full knee extension to VMO atrophy has led to the belief that VMO has its main role in the last 15º of active knee extension. Many conservative treatments were based on this hypothesis. In contrast, recent studies have failed to find selective VMO activity in this arc[5]. In our study we have done a VMO Coordination test to find out the VMO dysfunction as described by Souza5. But most of the subjects showed a negative result even with severe symptoms that is most of these patients had no difficulty in accomplishing extension. Thus in our study VMO Co-ordination test showed no significance in both the groups.

Clinically relevant results were achieved without treatment strategies like taping and stretching regimens, which suggest that the underlying cause of Patellofemoral pain syndrome(PFPS) may not be restricted to the Patellofemoral joint(PFJ). Mascal et al [6] did case studies and suggested that patients with PFPS demonstrated abnormal kinematics at the hip that responded favorably to an exercise programme specifically targeting the hip, pelvis and trunk musculature.

Turnia et al[7] have proposed that the increased risk of PFPS in females was due to structural differences in the pelvic width, femoral anteversion, 'Q' angle, tibial torsion, hormonal differences and the effect of estrogen on the connective tissues. In our study the two groups were divided with equal number of males and females. Thus, statistically it showed that age is not significantly varying among the groups as the mean age in Group 1 and Group 2 was 25.85 and 27.65 respectively.

Herrington et al[8] found that the relative difference in the overall activity between VMO and VL was not influenced by gender, hip position and mode of exercises. The findings of their study indicates that when choosing exercises for the rehabilitation of patients with patellofemoral pain, the aim would be to select exercises which minimize joint loading rather than exercises which recruit VMO as this would be unlikely to occur. Therefore, in our study we have followed the exercises with minimal joint loading and specific degrees of knee movements, i.e. 90º to 50º in OKC and 0º – 40º in CKC.

In our study, most of the patients have more pain during descending stairs than ascending. This could be explained by a study on PFJ stresses. During stair ascent Patellofemoral Joint Reaction Force (PFJRF) decreases because of decreased cadence and the forward lean of the trunk, thereby reducing the knee extensor moment. During stair descent, there is no significant reduction in the PFJRF and the PFJ stress value remains the same. On comparison of ascending and descending stairs, the PFJ stress – time integral is 1.5 times greater than descending stairs and thus an increase in pain is felt during descent[9],[10]

As there are not many studies done on role of Rectus femoris in patients with patellofemoral pain syndrome we suggest that further studies to be done to find out the relationship between rectus femoris with vastus medialis obliquus and vastus lateralis rehabilitation.

Limitations of the study

Most of the chief complaints of the patients were pain during kneeling but the AKPS does not have a question related to kneeling. Some of the questions on the AKPS have posed a problem for patients including 'atrophy of the thigh', 'flexion deficiency' and 'subluxation.' VMO Co-ordination test, which was considered to be a diagnostic test for PFPS, also gave negative results in many subjects with PFPS. VMO Coordination test may hence, not be considered as a diagnostic test in patellofemoral pain syndrome (PFPS).

Future Scope

Further research is warranted to determine the relationship between rectus femoris and vastus medialis obliquus by using electromyographic study, and another study can be done on the existing Anterior knee pain scale questionnaires could be modified or the development of a more responsive questionnaire could be devised which can include all the factors of patients with patellofemoral pain syndrome. Further study can be done on Athletes with patellofemoral pain syndrome to find efficacy of rectus femoris with vastus medialis obliquus. Comparative study between rectus femoris and vastus medialis obliquus can be done using different treatment methods like taping, ultrasound therapy in patients with patellofemoral pain syndrome.

CONCLUSION

In this study it was found that vastus medialis obliquus strengthening is more effective compared to strengthening of rectus femoris in patients with patellofemoral pain syndrome.

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ISSN: 2231-2196 (Print) ISSN: 0975-5241 (Online)

COMPARISON OF PROCESS MINING ALGORITHMS WITH ASSOCIATION RULE MINING ALGORITHMS

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ABSTRACT

In the recent studies says that is the state of the art of process mining algorithms were used in different applications such as healthcare, sales and inventory, etc. But in my previous research paper, first time we have implemented the process mining algorithms in the domain of dyeing units. Normally, the dyeing unit is complex in nature, because it involves dynamic features in the process. Moreover, it is also critical to keep a check on the automated processes to produce the expected results in the form of quality and timely dyeing processes. Delivering these processes is a complex, because colour shades are difficult to identify the little difference and also various dyeing problems were identified after dye mix. The main process of dyeing process is dye mix process; it involved various treatments, these treatments were very difficult to maintain the shade matching. Therefore, the process mining algorithms were used to identify the better process control against the difficulties of dyeing process. These process mining algorithms produce a diagrammatic process model, which is very easy to understand by the dyers, but when the process has more number of activities then the complex process models were produced. The outcome of these process models were not easy to understand, so some clustering techniques were used but at the same time the missing activities produce more noise, that is the process model after clustering misses the originality. To overcome these limitations, the association rule mining algorithms were used in the domain of dyeing unit and the related issues are also compared in this paper.

Keywords: Dyeing unit, process mining, association rule mining, clustering, dye mix, shade

INTRODUCTION

The limitations of the process mining algorithms such as Heuristic Miner (HM) and the Disjunctive Workflow Schema (DWS) were seen as the need to search for a process model representation that overcomes these limitations. Below it was stated that these limitations and comparison with the association rule mining algorithm LinkRuleMiner (LRM) with the results of HM and DWS mining algorithms. The HM is one of the most robust algorithms available till date for logs containing noise and imbalance. Weijters et al. [1] conducted experiments with the HM on the benchmark artificial material. The result of these experiments emphasized the robustness of the algorithm in situations of noise and imbalance present in the log in various degrees. However the experiments were conducted on artificial material and using the default parameter settings of the algorithm.

When the algorithm was applied to two dyeing process implementations i.e. Emerald and Jayabala dyeing units, It is identified that the results of the HM are not what the dyers or experts were expecting, hence the alternative process model for the dyeing process need to be identified. Therefore, the association rule mining algorithms were used as a new approach to implement the dyeing industries, dyeing processing system with various association mining algorithms such as Apriori, FPGrowth, HMine and LinkRuleMiner were discussed.

The limitation of HM, DWS vs. LRM

The purpose of the HM process mining algorithm is to discover the process model underlying the investigated process. Hence, it is performed with many experiments with different parameter settings but the algorithm failed to provide a clear and understandable process model [2]. The process models obtained were complex and full of problems like missing activities (activities registered in the event log but not captured in the process model), missing dependencies and dangling activities. When the dyeing logs were mined without using the all-activities connected heuristic the process model obtained for some logs were better in terms of simplicity. But these models were full of disconnected and dangling activities, and therefore these models do not exhibit those connections that were shown by the models generated using the all-activities connected heuristic parameter. So, it could not be concluded whether not using the all-activities connected heuristic is a good choice. [3].

comparison of HM, DWS process mining algorithms with linkruleminer association rule mining algorithm

The LRM however can be compared to the results of the HM as they both generate different process models. The HM generates a dependency graph and the LRM generates association rules. The limitations of the HM therefore are not dealt with in the LRM. The LRM just provides an alternate process model representation different from the one based on the pure control flow. The LRM gives insights into the process but not in form of a visual process model like the Petri nets or the dependency graph. However, these process models can be obtained using the clustered Pis from the LRM using some mining algorithm available in ProM [4] [5]. Our purpose behind the proposal and implementation of the LRM was not to replace the HM but was to obtain behavioural insights into the underlying process. This behaviour is not explicitly presented in a dependency graph. Moreover, it should be noted that the LRM is able to deal with noise if noise refers to the errors done in recording the activities in their proper execution order [6]. As the association rules only represent the associations between the activities purely based on their execution, therefore if any log does not have the 'timestamp' information, the association rules would still be consistent. This was observed in the Jayabala dyeing units dyeing process because in this implementation the 'timestamp' information of the activities is missing and only the date is recorded [7]. If such logs are given to the HM and the DWS algorithms, they may not be able to generate correct models as the dependency graph will still depict the erroneous dependencies, and also the discriminant rules [8] will portray wrong results. Though the LRM seems to be a good approach for mining flexible processes, it can be improved to provide better results. The next section illustrates the experiment with an example of dyeing process.

Comparison between DWS and LRM algorithms: A Case Study

To demonstrate the implementation of DWS algorithm in the domain of dyeing process, the three shades dyeing process is taken from Emerald dyeing unit. The three shades dyeing process has 683 PIs, 70 different ATEs and 12,294 total number of ATEs. The cluster log is derived from the DWS process mining algorithm is shown in the figure 1. Then the exported cluster log is given as input to HM

algorithm to produce the simplified process model. It is identified that the whole log is very complex to understand than the clustering log. To compare the association rule mining algorithm LRM, the same event log is taken for the study. The Weka library produces the association rules for the given parameter settings as a input. Hence, the LinkRuleMiner (LRM) algorithm produces the same 10 association rules as shown in Figure 2. The LRM algorithm has the effective results with the performance of less memory overhead and high speed. These LRM association rules would help us in obtaining simpler and understandable process models that give meaningful insights into the underlying process. For this experiment the same log as used for DWS is used. As it is know that it has 683 process Instances (Pis), 70 different Event logs and 12,294 total numbers of ATEs are used to illustrate the LinkRuleMiner algorithm. The minimum support for the upper bound is set to 0.7 and the confidence is set to 0.9 to illustrate this algorithm. Hence, the Figure 2 gives the process model generated by this algorithm. The LinkRuleMiner algorithm modifies link structure and processing order of HMine algorithm. It has successfully removed link adjustment from H-Mine without any loss in performance and thus makes it possible to do parallelization on the algorithm efficiently. Therefore, the LinkRuleMiner algorithm that has no link adjustment made it possible to build parallel algorithm that requires no data exchange or any communications between each node in the middle of mining process. This allows us to build ideal parallel algorithm in shared disk environment and further to design parallel algorithm that exchanges data and communicates between each node in an efficient way in shared nothing environment.

The figure 2 has 10 different association rules, which has different confidence values, from these rules, the high confidence rule has major association between activities and the minimum confidence rule has the minor association between activities. Also, these rules identify the relationship between the processes of dyeing. The one or more activities are combined in some rules, because more than one rule can participate in the same treatments. Hence, the dependency is identified very easily even for high number of event logs. But in the case of process mining algorithms HM and DWS it is not possible to identify the association between activities, but the DWS algorithm produce the discriminant rule, which has the relationship between activities, but this does not give the confidence measures. Therefore, from this we conclude that the association rules were very easy to understand and very helpful to identify the importance of activities and also the sequence of operations with the help of support and confidence features available in this algorithm. Hence, the dyers can easily identify the interrelationship between treatments, dependant, independent treatments and worker workload. Before concluding the comparative study the following experiment also conducted for Jayabala dyeing unit. This event has hundred shades. The hundred shades dyeing process of Jayabala dyeing

unit computes the association rules in 0.124 seconds. This has the 10 different rules and each represents the different confidence, lift values. It is shown in the figure 3 and 4.

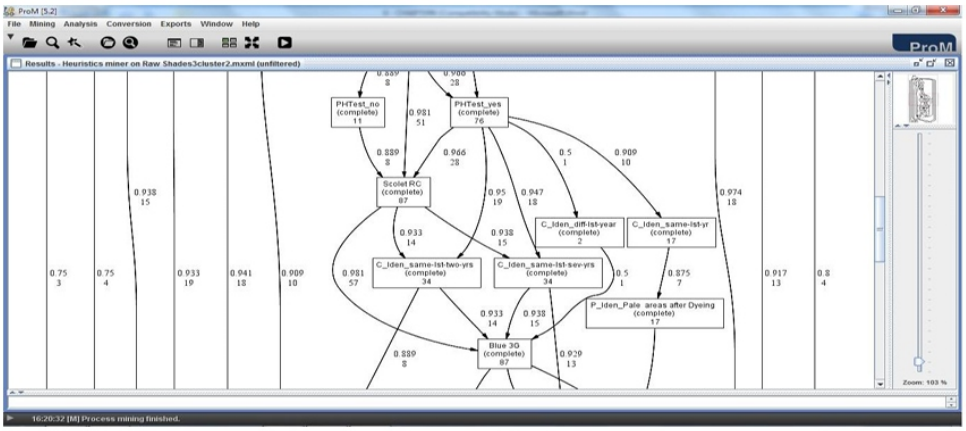

Figure 1: Process model of three shade dyeing process Cluster for Emerald dyeing unit with 683 PIs, 70 different ATEs and 12,294 total numbers of ATEs.

```
=== Associator model (full training set) ===

LinkRuleMiner found 16 rules (displaying top 10)

 1. [PH_Neu_normal=yes]: 440 ==> [Scolet RC=yes]: 440   <conf:(1)> lift:(1.03) lev:(0.02) conv:(12.88)
 2. [PH_Res_abnorm=yes, CT_highcont=yes]: 432 ==> [Scolet RC=yes]: 432   <conf:(1)> lift:(1.03) lev:(0.02) conv:(12.65)
 3. [Post_Treat_Absent=yes, CT_highcont=yes]: 425 ==> [Scolet RC=yes]: 425   <conf:(1)> lift:(1.03) lev:(0.02) conv:(12.45)
 4. [ShadeCheck_Good=yes, CT_highcont=yes]: 411 ==> [Scolet RC=yes]: 411   <conf:(1)> lift:(1.03) lev:(0.02) conv:(12.04)
 5. [ShadeCheck_Good=yes, PH_Neu_normal=yes]: 430 ==> [Scolet RC=yes]: 430   <conf:(1)> lift:(1.03) lev:(0.02) conv:(12.59)
 6. [ShadeCheck_Good=yes, PHTest_yes=yes]: 438 ==> [Scolet RC=yes]: 429   <conf:(0.98)> lift:(1.01) lev:(0.01) conv:(1.28)
 7. [PH_Res_abnorm=yes, PHTest_yes=yes]: 437 ==> [Scolet RC=yes]: 428   <conf:(0.98)> lift:(1.01) lev:(0.01) conv:(1.28)
 8. [Post_Treat_Absent=yes, PHTest_yes=yes]: 430 ==> [Scolet RC=yes]: 421   <conf:(0.98)> lift:(1.01) lev:(0.01) conv:(1.26)
 9. [PH_Neu_normal=yes]: 440 ==> [ShadeCheck_Good=yes]: 430   <conf:(0.98)> lift:(1.18) lev:(0.1) conv:(6.85)
10. [PH_Neu_normal=yes]: 440 ==> [Scolet RC=yes, ShadeCheck_Good=yes]: 430   <conf:(0.98)> lift:(1.22) lev:(0.11) conv:(8.02)
```

Figure 2. The simple process model by LRM algorithm generated Association Rules from Weka tool with PIs = 683 and Event Logs =12,294

```
=== Associator model (full training set) ===

LinkRuleMiner found 20 rules (displaying top 10)

 1. [Post_Treat_Absent=yes, PH_Neu_normal=yes]: 301 ==> [ShadeCheck_Good=yes]: 297   <conf:(0.99)> lift:(1.17) lev:(0.07) conv:(9.23)
 2. [Pre_Treat_Absent=yes]: 305 ==> [PH_Res_abnorm=yes]: 299   <conf:(0.98)> lift:(1.11) lev:(0.05) conv:(4.94)
 3. [ShadeCheck_Good=yes, Pre_Treat_Absent=yes]: 294 ==> [PH_Res_abnorm=yes]: 288   <conf:(0.98)> lift:(1.1) lev:(0.05) conv:(4.76)
 4. [CT_highcont=yes, PH_Neu_normal=yes]: 287 ==> [ShadeCheck_Good=yes]: 281   <conf:(0.98)> lift:(1.16) lev:(0.06) conv:(6.29)
 5. [PH_Neu_normal=yes]: 387 ==> [ShadeCheck_Good=yes]: 376   <conf:(0.97)> lift:(1.15) lev:(0.08) conv:(4.95)
 6. [CM_ReactiveDyes=yes]: 339 ==> [ShadeCheck_Good=yes]: 329   <conf:(0.97)> lift:(1.15) lev:(0.07) conv:(4.73)
 7. [PH_Res_abnorm=yes, PH_Neu_normal=yes]: 348 ==> [ShadeCheck_Good=yes]: 337   <conf:(0.97)> lift:(1.14) lev:(0.07) conv:(4.45)
 8. [PHTest_yes=yes, PH_Neu_normal=yes]: 316 ==> [ShadeCheck_Good=yes]: 306   <conf:(0.97)> lift:(1.14) lev:(0.06) conv:(4.4)
 9. [PH_Res_abnorm=yes, CM_ReactiveDyes=yes]: 307 ==> [ShadeCheck_Good=yes]: 297   <conf:(0.97)> lift:(1.14) lev:(0.06) conv:(4.28)
10. [PH_Res_abnorm=yes, PHTest_yes=yes, PH_Neu_normal=yes]: 282 ==> [ShadeCheck_Good=yes]: 272   <conf:(0.96)> lift:(1.14) lev:(0.06) conv:(3.93)
```

Figure 3. Association rule mining Process model using LRM algorithm of hundred shades dyeing process for Jayabala dyeing unit of Whole log with 600 PIs, 262 different ATEs and total number of ATEs of 10,200

```
LinkRuleMiner found 20 rules (displaying top 10)

 1. [Post_Treat_Absent=yes, PH_Neu_normal=yes]: 301 ==> [ShadeCheck_Good=yes]: 297   <conf:(0.99)> lift:(1.17) lev:(0.07) conv:(9.23)
 2. [Pre_Treat_Absent=yes]: 305 ==> [PH_Res_abnorm=yes]: 299   <conf:(0.98)> lift:(1.11) lev:(0.05) conv:(4.94)
 3. [ShadeCheck_Good=yes, Pre_Treat_Absent=yes]: 294 ==> [PH_Res_abnorm=yes]: 288   <conf:(0.98)> lift:(1.1) lev:(0.05) conv:(4.76)
 4. [CT_highcont=yes, PH_Neu_normal=yes]: 287 ==> [ShadeCheck_Good=yes]: 281   <conf:(0.98)> lift:(1.16) lev:(0.06) conv:(6.29)
 5. [PH_Neu_normal=yes]: 387 ==> [ShadeCheck_Good=yes]: 376   <conf:(0.97)> lift:(1.15) lev:(0.08) conv:(4.95)
 6. [CM_ReactiveDyes=yes]: 339 ==> [ShadeCheck_Good=yes]: 329   <conf:(0.97)> lift:(1.15) lev:(0.07) conv:(4.73)
 7. [PH_Res_abnorm=yes, PH_Neu_normal=yes]: 348 ==> [ShadeCheck_Good=yes]: 337   <conf:(0.97)> lift:(1.14) lev:(0.07) conv:(4.45)
 8. [PHTest_yes=yes, PH_Neu_normal=yes]: 316 ==> [ShadeCheck_Good=yes]: 306   <conf:(0.97)> lift:(1.14) lev:(0.06) conv:(4.4)
 9. [PH_Res_abnorm=yes, CM_ReactiveDyes=yes]: 307 ==> [ShadeCheck_Good=yes]: 297   <conf:(0.97)> lift:(1.14) lev:(0.06) conv:(4.28)
10. [PH_Res_abnorm=yes, PHTest_yes=yes, PH_Neu_normal=yes]: 282 ==> [ShadeCheck_Good=yes]: 272   <conf:(0.96)> lift:(1.14) lev:(0.06) conv:(3.93)

=== Evaluation ===

Elapsed time: 0.124s
```

Figure 4. Association rule mining Process model using LRM algorithm of hundred shades dyeing process for Jayabala dyeing unit of Whole log with 600 PIs, 262 different ATEs and total number of ATEs of 10,200 with execution time

LIMITATIONS OF THE LINKRULEMINER ALGORITHM

The association rule mining algorithm LRM has limitations with respect to frequent pattern by comparing with other algorithms available in traditional data mining. These limitations are stated below.

- Every association rule algorithm first generates frequent itemsets and then derives association rules from these frequent itemsets. Computational requirements for frequent itemset generation are generally more expensive than those of rule generation. When the value of the support thresholds is lowered it results in more itemsets declared as frequent. This increases the computational complexity of the algorithm because candidate itemsets must be generated and counted. The maximum size of frequent itemsets also increases with lowering the support threshold values. With this increase, the algorithm has to make more passes over the dataset. The total number of iterations required by the algorithm is kmax +1, where kmax is the maximum size of the frequent itemsets. Therefore, when lower support values are given to the algorithm to generate rules involving low frequent activities, the computational complexity also increases, thereby degrading the performance of the LRM in terms of computation time.

- When more itemsets (activities or group of activities) are declared as frequent itemsets more space is needed to store the support count of these items. This increase in the number of events increases the computation and I/O costs as larger number of candidate itemsets will be generated by the algorithm.

- The Apriori algorithm makes repeated passes over the data set therefore its run time increases with the size of the dataset. If the number of PIs in the event log is large the runtime for the algorithm also increases. For the LRM algorithm also the computation time increases linearly with an increase in the number of Pis.

- Also if the width of PIs is large i.e. the number of ATEs contained in a PI is large then the number of hash tree traversals performed during the support counting is also increased. This also consumes a lot to time.

- The association rule algorithms do not deal with length-one-loops. For example, if an event log contains traces of the type "…aa…" it does not generate a rule showing that the task 'a' is in loop with itself. So, this information is missing in the LRM. But it is capable of dealing with loops involving more than 1 task i.e. length two or three loops.

- The confidence measure ignores the support of the itemset in the rule consequent. Due to this some high confidence rules can sometimes be misleading [9]. A better metric like the lift can be used to indicate interesting rules. Lift is a metric that also considers the support count of an association rule.

- Practically, by varying the values of the confidence and support parameters in the Apriori algorithm hundreds of association rules can be generated. But many of these rules are redundant and do not provide any new information. So, the search of interesting and non-redundant association rules is a very popular research topic.

- In the LRM, it is identified that the user can use the original Apriori algorithm but it is also identified that the user can apply the concept of interesting rules to retain only the non redundant rules. That means that the user can still take the output of the Apriori and then apply our filters. This consumes extra memory and time as many frequent itemsets are computed without any use as the rules that may be generated from them are eventually discarded because they may be redundant rules. It means a new concept for the association rule algorithm should be proposed that generates only the nonredundant rules and the frequent itemsets are generated accordingly.

- The frequent itemset generation in the FPGrowth algorithm is also computationally expensive. The latter minimizes the number of database passes by representing the transactional dataset in vertical layout (storing the list of transaction identifiers) rather than the horizontal layout storing the transactions themselves.

CONCLUSION

In this paper, it is presented with the experiments of the Emerald and Jayabala dyeing unit‘s dyeing process using the LRM algorithm. Hence, it is analyzed the association rules and understood the strengths of these rules indicated by confidence and predictive accuracy metric. It was established that association rules and frequent itemsets represent behavioral and frequent patterns in event logs which are not explicitly communicated by a process model (like Petri net, dependency graph etc.) mined using some mining algorithm. These frequent patterns can be further used as a criterion for the event log into clusters that satisfy a particular behavioural pattern and the ones that do not satisfy this pattern. These clustered process instances can be supplied as input to some mining algorithms to gain specific process models exhibiting homogeneity of cases. Hence, this paper discussed about the process mining algorithms HM and DWS were investigated against the association rule mining algorithms. In spite of the limitations of the association rule algorithms implemented in the LRM, the LRM can be used for mining complex and less-structured processes from domains like the dyeing to determine homogeneous care flow paths.

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